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# WEATHER SCENARIOS FOR DOSE CALCULATIONS WITH INCOMPLETE METEOROLOGICAL DATA

## VOLUME 1

by

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Research report

# WEATHER SCENARIOS FOR DOSE CALCULATIONS WITH INCOMPLETE METEOROLOGICAL DATA

## ABSTRACT

This report documents a study to substantiate or modify the weather scenarios proposed in the AECB staff Position Paper on meteorological acceptance criteria for estimating the potential radiological consequences of postulated accidents (AECB, 1982) for short-, prolonged-, and long-term releases from ground level and elevated sources.

The study examined selected meteorological data in Canada to determine whether the AECB proposed scenarios are sufficiently general that they are appropriate and conservative for nuclear power plant sites in Canada, but also realistic, i.e., not so conservative, that the results of dose calcultations using these scenarios would be wholly unrepresentative, leading to incorrect design decisions.

Three sets of site-specific meteorological data were used to derive a recommended general weather scenario set, which was then compared with the AECB proposed scenarios. The recommended scenarios are, in general, more conservative.

Several recommendations for future work are presented in chapter G.

## RÉSUMÉ

Le présent rapport documente l'étude entreprise pour appuyer ou modifier les scénarios météorologiques proposés dans le mémoire des agents de la CCEA sur les critères météorologiques acceptables pour estimer les conséquences radiologiques possibles des accidents postulés (CCEA, 1982) dans le cas des rejets à court, moyen et long termes, provenant de sources au niveau du sol ou de sources élevées.

L'étude a examiné des données météorologiques canadiennes sélectionnées afin de déterminer si les scénarios proposés par la CCEA sont suffisamment généraux pour s'appliquer de façon prudente aux sites de centrales nucléaires au Canada, mais aussi réalistes, c'est-à-dire non pas si prudents que les résultats des calculs de doses établis à partir de ces scénarios ne seraient pas du tout représentatifs, causant ainsi des décisions mal fondées au niveau de la conception.

Trois séries de données météorologiques particulières à des sites ont été utilisées pour dériver un ensemble de scénarios météorologiques généraux à recommander, que l'on a ensuite comparé aux scénarios proposés par la CCEA. Les scénarios recommandés sont, en général, plus prudents.

Le chapitre G fait plusieurs recommandations pour le travail à venir.

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## SUMMARY

This report documents a study to substantiate or modify the weather scenarios proposed by the Atomic Energy Control Board Staff Position Paper on meteorological acceptance criteria for estimating the potential radiological consequences of postulated accidents (AECB, 1982) for short-, prolonged-, and long-term releases from ground level and elevated sources.

The study examined available meteorological data in Canada to determine whether the AECB proposed scenarios are sufficiently general that they are appropriate and conservative for any potential nuclear power plant in Canada, but also realistic, i.e., not so conservative, that the results of dose calculations using these scenarios would be wholly unrepresentative, leading to incorrect design decisions.

The examination of meteorological data consisted of analyzing the hourly time series of meteorological parameters that are relevant to pollutant dispersion in the atmosphere (such as wind speed, wind direction, atmospheric stability) for lag correlations between a given weather condition at the beginning of a release (i.e., "start condition") and subsequent atmospheric conditions hours, days, and weeks later. Discrete classes were used for the meteorological parameters to simplify the analyses. Time series of atmospheric conditions (weather scenarios) were then derived from the resulting weather patterns such that the time integrated concentration that would result from the longest scenario considered in the study (30-day) would be exceeded only 10% of the time if real 30-day weather scenarios for several years were used.

Two sets of weather scenarios were derived, one for ground-level and the other for elevated releases (at 50 m). The scenarios are progressively more conservative when used for shorter time periods (i.e., <10% to 0% exceedance). Thus, the shortest-duration (1-hr) scenario consists of a worst case weather condition whose corresponding time integrated concentration is never exceeded (0% exceedance). This particular weather condition (very low wind speed and stable atmosphere) occurs only about 5-10% of the time in reality.

Meeting the 10% exceedance criterion for the shorter-duration scenarios (as opposed to the 0% to <10% exceedance that result from the use of the 30-day scenarios for shorter time periods) would have required a completely different scenario for each release duration. The method developed in this study is fully applicable to deriving such scenarios and they had been developed during the course of the study for one site for seven different release durations. However for reasons of practicality, especially when scenarios which have not been developed for release durations other than the above seven durations and which might be required for various safety analyses are considered, specification of a single scenario for all release durations was deemed necessary during discussions with the AECB staff and the Scientific Authority. A method that would yield more conservative scenarios for shorter releases than for longer releases was then considered desirable. The method developed in this project satisfies this criterion.

The release scenario used in the calculation of time integrated concentrations for the various duration (1 hr to 30 days) scenarios is unit release for each hour. The time integrated concentrations corresponding to each atmospheric

condition were calculated using the formulations in the draft CSA Standard N288.2 (CSA, 1985) with specific input parameter values somewhat representative of nuclear power station geometries and sites in Canada.

Three different sets of scenarios were derived using three site-specific data sets from weather stations that are representative of existing nuclear power plants in Canada.

When compared, these scenarios for the three sites are not significantly different from each other, especially in terms of trends, considering that they have been based on data from widely differing meteorological regions in Canada. This could be viewed as an advantage of the methodology developed in the present project in that it is rather robust with respect to regional differences. Thus, we can have reasonable confidence in using for various regions a single scenario based on a conservative envelope of these three sets of scenarios.

Conservative envelopes of the scenarios for the three sites were taken to given the recommended general weather scenario set. The recommended set was then compared with the AECB proposed scenarios. The recommended scenarios are in general more conservative.

In the approach developed in the study, there are three main areas which are designed to ensure conservatism of the scenarios derived from real data, so that these scenarios can be used with some confidence of safety for sites with no data. These areas are i) the selection of the lower limit of each discrete wind speed class as the representative value for that class, and ii) superposition of the realistic conservative wind speed-stability scenario with the realistic conservative wind direction scenario to form a combined weather scenario, iii) selection of the conservative envelope of the scenarios for the three sites.

It is noted that, the recommended scenarios are intended for use within the N288.2 framework, and only when no adequate on-site or representative weather station data are available. For preliminary safety analyses, use of meteorological data from a representative weather station, if available, is preferable over the use of the recommended scenarios. For final safety analyses, use of on-site data are recommended. A discussion of how safety analyses should be conducted when on-site or representative station data are available is beyond the scope of this project.

Several recommendations for future work have resulted from this study. These are presented in Chapter G. The more significant ones are noted below.

- As a direct test of the pattern analysis method developed in this study, it is recommended that time integrated concentrations for real scenarios of different durations for one site be calculated, taking into account wind direction changes as they occur, and compared with those estimated using the recommended scenarios. This would be done using the dispersion model and input parameters as used in the present study so that the effects of the pattern analysis method can be isolated from the effects of the dispersion model and input parameters. This comparison would also provide a direct test of applicability of the recommended scenarios.

- For the purposes of refining the dispersion model and the input parameters used in the study, it is recommended that

- use of a more suitable dispersion model for low wind speeds,
- effect of lake- and sea-breeze situations, and
- effect of taking meandering into account through the dispersion parameters throughout the pattern analysis rather than including it at the end, be investigated.

- For the purpose of rendering the recommended scenarios more suitable for dose calculations, it is recommended that the implications of the scenarios on dose calculations be investigated by including dose calculations as an extension to the dispersion model throughout the pattern analysis, for a selected site, release height and radioisotope.

## RESUMÉ

Ce rapport décrit une étude qui verifie ou modifie les déroulements de météo soumis par les personnel du Bureau de Controle de l'Energie Atomique discuté en un papier definitif concernant les critères météorologiques acceptées. Celles-ci estiment les conséquences radiologiques potentielles des accidents postulés (BCEA, 1982) pour les émissions avec une duration courte, prolongée ou longue au niveau du sol et aux sources élevées.

L'étude a examiné les avalables chiffres méteorologiques au Canada pour determiner si les déroulements proposé par le BECA sont suffisament genérals, s'ils sont apropos et conservatives pour n'importe quel usine potentielle de puissance nucléaire au Canada, mais aussi avec réalisme, dire que pas si conservatif que les résultats des calculs de dosage en utilisant ces déroulements ne seraient pas complètement non-representatifs et par conséquent, de faussement decider les dessins.

L'examination des chiffres méteorologiques a encompassé l'analyse des paramètres méteorologiques des series de temps horaire pertinant à la dispersion des pollutants de l'atmosphère pour les correlations de delai entre une ci-donnée condition de temps au début d'une émission (dire que la 'condition débutante') et les conditions atmospheriques subséquents aux intervales horaires, quotidiennes et hebdomadaires. Alors que les series du temps des conditions atmospheriques (les déroulements de météo) seraient dérivées des patternes resultants de météo par la facon que la concentration du temps integré qui pourrait etre atteint du déroulement le plus long examiné en l'étude (30 jours) ne serait plus en excès de 10 pourcent du temps si on utilise les déroulements réels de météo pour 30 jours pendant plusieurs années.

Deux ensembles des déroulements de météo étaient dérivées. L'un pour le niveau du sol et l'autre pour les émissions aux points élevés (à 50 m). Les déroulements sont progressivement plus conservatifs quand ou les utilise pour les périodes de temps plus courtes (dire que moins de 10 pourcent jusqu' à 0 pourcent en excès). Par conséquent, le déroulement le plus court en duration incluit la condition de météo pour le cas pire pour lequel la condition intégrée du temps n'est jamais en excès de 0 pourcent. En realité, cette condition particulière de météo (une très basse vitesse du vent et une atmosphère stable) existe seulement pour 5 à 10 pourcent du temps.

En achevant la critère de 10 pourcent en excès pour les déroulements d'une duration plus courte (par contraste aux situations de 0 pourcent à moins de 10 pourcent en excès qui resultent en l'utilisation des déroulements de 30 jours pour les plus courtes périodes) pourraient avoir requis un déroulement complètement différent pour chaque duration d'une émission. Tels déroulements avaient été developpé pendant une étude pour une site avec sept durations différents d'émissions. Cependant, pour les raisons practicales, espécialement quand ou considère que ces déroulements pour ces sept durations d'émissions sont les seules situations avalables et il faut qu'on ait les autres durations pour les analyses de sécurité, on doit specifier un seul

déroulement pour toutes les durations d'émission. Conséquemment, une méthode qui prévoit de plus conservatives déroulements pour les plus courtes émissions en comparaison de plus longues émissions était désirable.

Le déroulement d'émission qu'on utilise pour le calcul des concentrations intégrées du temps pour les déroulements d'une duration variable (1 h à 30 jours) est l'émission unitaire pour chaque heure. Les concentrations intégrées du temps correspondant à chaque concentration atmospherique étaient calculées en utilisant les formules dans la draft-copie de L'Etendard N288.2 (CSA, 1983) avec les valeurs des soumises paramètres specifiques qui partiellement represente les géometries et les sites pour les usines de puissance nucléaire au Canada.

En comparaison, ces déroulements pour les trois sites ne sont pas différentes en significance de l'un à l'autre, particulièrement en tendance si ou considère qu'ils ont été basé aux chiffres de vastement différents régions météorologiques au Canada. On pourrait regarder ces resultats comme une avantage de la methodologie qu'on a developpé en le ci-present project pour la raison qu'elle est suffisament flexible en regard des différences régionales. Pour cette raison, nous pouvons avoir de la confiance raisonable en utilisant un seul déroulement pour les divers régions qui est basé sur une enveloppe conservative de ces trois ensembles de déroulement.

Les enveloppes conservatives des déroulements pour les trois sites étaient accepté de donner le racommandé ensemble de déroulement pour la météo en général. Ensuite, le racommandé ensemble était comparé avec les déroulements proposé par le BCEA. Les déroulements racommandés sont plus conservatifs en général.

On a noté que les déroulements racommandés sont dessinés pour les utiliser en dedans le coup d'ouvrage de N288.2, et seulement quand ils n'y ont pas des en-emplacements chiffres adéquats ou representatifs d'un bureau de météo. Pour les analyses préliminaires de sécurité, l'utilisation des chiffres météorologiques d'un bureau de météo representatif, si avalable, est preférable en place de l'utilisation des déroulements racommandés. Une discussion de la procédure de faire les analyses de sécurité quand les en-emplacements ou representatifs chiffres d'un bureau sont avalables est au dehors du champ de ce project.

Nous sommes arrivés à plusieurs racommendations pour l'oeuvre à l'avenir au cours de cet étude. Celles-ci sont presentées en chapitre G. Les uns de plus significance sont notées ci-bas.

- Comme un test direct de la méthode pour l'analyse des patternes qu'on a developpé en cet étude, nous avons racommandé que les concentrations integrées du temps pour les réels déroulements de differents durations d'une site est calculé, se rendant compte que les changements de la direction du vent quand il prend place, et les comparer avec eux qu'on estime en utilisant les déroulements racommandés. Cette comparaison serait faite par la modèle pour la dispersion et les soumises paramètres utilisé en cet étude afin d'isoler les effets de la méthode pour l'analyse des patternes et les effets de la méthode pour la dispersion et les soumises paramètres. Cette comparaison aussi donnerait un test direct de l'application des déroulements racommandés.

- Pour le but de raffiner la modèle pour la dispersion et les soumises paramètres de cet étude, nous avons racommandé que:
  - on utilise une plus converable modèle pour la dispersion aux courtes vitesses du vent
  - on considère l'effet des situations influencés par le vent du lac ou de la mer, et
  - on se rend compte de l'effet de la serpentation en examinant les paramètres pour la dispersion partout dans l'analyse des patternes plutot que son inclusion à la fin.
- Pour le but de mettre en scène ces deroulements racommendés plus convenables pour les calculs de dosage, il fallait que les implications des déroulements sur les calculs de dosage soient examiné en incluisant les calculs de dosage comme une extension de la modèle pour la dispersion partout dans l'analyse des patternes, pour une site choisisse, une ci-donnée élevation d'émission et une radioisotope.

# WEATHER SCENARIOS FOR DOSE CALCULATIONS WITH INCOMPLETE METEOROLOGICAL DATA

## A. INTRODUCTION

This is the final report on a project carried out by Concord Scientific Corporation (CSC) for the Atomic Energy Control Board (AECB) under the Supply and Services Canada contract, Serial No.: 0SQ84- 00025.

The objective of the work program carried out in this project is to substantiate or modify the weather scenarios proposed by the AECB Staff Position on meteorological acceptance criteria for estimating the potential radiological consequences of postulated accidents (AECB, 1982), by examining existing meteorological records in Canada and existing regulatory positions in other countries.

The AECB has specified conservative weather conditions which licensees are required to use in calculation of public dose if applicable weather data are not available for the actual site chosen for a nuclear power plant (Hurst and Boyd, 1972). At the time that these conditions were specified, releases of radioactive material were expected to be ground level and of short duration, and the licensee was required to assume Pasquill F stability conditions in any analysis of radiation dose to the public.

More recent analyses have shown that releases could be at ground or elevated level, and, perhaps more importantly, could occur over several days or even weeks. Since atmospheric dispersion conditions are highly variable in both space and time, and generally undergo significant variations over a period of even one day, it is considered unnecessarily conservative to assume that the stable Pasquill Category F persists for the entire period during these long release durations (see for example Figure 2.19 of Slade (1968), which presents the average diurnal variation of the vertical temperature structure at a particular site). The AECB (1982) has therefore proposed revised weather conditions which attempt to present a more balanced "mix" of actual weather variations occurring over several days or weeks.

The above has led to this research project, which examined available meteorological data in Canada to determine whether the AECB proposed conditions are sufficiently general that they are appropriate and conservative for any potential nuclear power plant in Canada, but not so conservative that the results of dose calculations using these conditions would be wholly unrepresentative, leading to incorrect design decisions. The study of meteorological data and the review of existing regulatory positions in other countries produced a body of information which provided direction in making "appropriate" modifications to the proposed weather scenarios.

### 1. Definition of a "Realistic Conservative" Scenario and Report Outline

Some care should be taken in defining what is meant by "appropriateness," since this has a significant bearing on the scope of the work program for this project. We shall now define this concept, while at the same time outlining major sections of the report.

In the present study, the methodology prescribed in the draft CSA Standard N288.2 (CSA, 1983) was used as the basis of modelling atmospheric dispersion of radioactive emissions from postulated accidents. The methodology of the draft Standard is outlined in Chapter B of this report to set the stage for the remainder of the report. This methodology requires a weather scenario as an input. If detailed meteorological data are available for the site, they should be used to define the required input weather scenarios. However, if data are not available, then conservative weather scenarios would be required. The literature survey conducted to identify past related work is described in Chapter C.

What is meant by "conservative" here is a scenario which maximizes "immediate exposure" (i.e., by submersion and inhalation) to individuals along the path of the released puff, as opposed to "chronic exposure" (i.e., by direct and indirect ingestion and external dose from deposited radionuclides) in the areas affected by the release.

The use of a "worst case" weather scenario, such as that described by Hurst and Boyd (1972) (Pasquill F stability), would be a realistic and conservative scenario if the accident scenario (release scenario) is ground level and short-term.

On the other hand, for elevated short-term releases, it is easy to show by several repeated applications of the draft Standard methodology that the above scenario may not always be the "worst case." This is fully recognized in Table 2 of the draft AECB Staff Position paper (AECB, 1982) and the "worst case" for elevated releases is defined by the envelope described in that table. Such a worst case will provide a realistic conservative scenario for dose calculations for short-term releases (i.e., there is certainly a reasonable chance that a release may happen during the worst possible weather conditions for a given site, and that these conditions may last for an hour).

For prolonged or long term releases, however, the assumption of the "worst case" weather conditions lasting over the duration of the release is conservative, but may not be realistic (i.e., it may be overly conservative), simply because weather conditions are known to change, often over the course of several hours. Application of overly conservative weather scenarios may lead to imposition of dose overestimates which could have significant adverse economic effects or which may not be practically achievable, and therefore is not desirable.

At this stage, it is imperative to select a criterion which could be used for deciding if a given weather scenario is realistic as well as conservative enough for the purposes of safety analyses. In consultation with the technical authority for the project, a "realistic conservative" scenario was defined as a scenario which would yield a time integrated concentration $\chi_{10}$ that will not be exceeded more than 10 % of the time if real weather scenarios are used. The 10 % value is in accordance with the methodology described in the draft Staff Position Paper (AECB, 1982) for cases when on-site data are available. It is clear that the 10 % value used here is not based on purely objective reasons (for example, a 5 % value is suggested in the US NRC Reg. Guide 1.145, 1983), and the pattern analysis method (see below) developed for this project can be applied for deriving more ($<10$ %) or less ($>10$ %) conservative weather scenarios.

The description above of the "realistic conservative" scenario based on $\chi_{10}$ basically defines the "appropriateness" of the scenarios mentioned in the beginning of this Chapter. In order to prescribe these realistic conservative weather scenarios for use in safety analyses, it is imperative to examine available meteorological data for suitably selected sites and to derive the appropriate scenarios from a systematic pattern analysis of these data.

The site selection process included first the selection of regions in Canada with distinct climatological characteristics, and examination of typical synoptic weather patterns for these regions; and then the identification within these regions of sub-regions with distinct meso-scale characteristics, and selection within these sub-regions of sites with available detailed meteorological data. The site selection process is described in Chapter D of this report.

Examination of these data for typical patterns of the parameters relevant to atmospheric dispersion was then carried out. A detailed description of the systematic pattern analysis method that was developed for this project is presented in Chapter E of this report using data from one of the selected sites, namely St. John Airport, as an example. Examination of data record duration that would be necessary for statistical representativeness of the weather scenarios is also described in Chapter E. The weather scenarios that resulted from the application of the pattern analysis method to data from the selected sites are presented in Chapter F.

In Chapter G, the weather scenarios identified through the above examination for each sub-region are combined to give the final recommended "realistic conservative" weather scenarios for ground and elevated releases that meet the $\chi_{10}$ criterion, and compared with those proposed in the AECB Staff Position Paper (AECB, 1982).

## B. PARAMETERS OF INTEREST IN DISPERSION CALCULATIONS

The basic criterion against which the selected weather scenarios are judged is a time integrated concentration $\chi_{10}$ which should not be exceeded more than a specified percentage (10 %) of the time if real time series data are used. The method used for calculating this time integrated concentration for the purposes of the present project, and the required meteorological input parameters for this calculation are presented in this section. The specification of these input parameters in a time series form constitutes the "weather scenarios" mentioned in the previous section.

### 1. Dispersion Calculation Method

The dispersion equation used in this project for the calculation of $\chi_{10}$ is the short-term dispersion equation given in the draft CSA Standard N288.2 (CSA, 1985). For the purposes of this project, the long-term dispersion equation would be equally applicable, since it is only used to identify the required input parameters for specifying the weather scenarios, and obtain the "conservativeness" of weather conditions relative to each other, as will be discussed in Chapter E. The equation used is:

$$\chi(x,y,z) = \frac{Q}{2\pi \bar{u} \Sigma_y \Sigma_z} \exp\left[\frac{-y^2}{2\Sigma_y{}^2}\right] \left\{\exp\left[\frac{-(z-H)^2}{2\Sigma_z^2}\right] + \exp\left[\frac{-(z+H)^2}{2\Sigma_z^2}\right]\right\} f(\Sigma_z, H, h_i) \qquad B.1$$

This equation describes the time integrated concentration $\chi(\mathrm{Ci \cdot s \cdot m^{-3}})$ at a point (x,y,z), due to the passage of a puff of activity Q(Ci) released instantaneously at (0,0,H). The other parameters are:

$x$ = horizontal distance in the downwind direction from the source (m),
$y$ = horizontal distance in the lateral direction (m),
$z$ = vertical distance (m),
$\bar{u}$ = effective transport wind speed at release height aligned with the x direction,
$\Sigma_y$ = parameter to characterize dispersion in the y direction corrected for building wake effect (m) and sampling time; function of downwind distance x and atmospheric stability,
$\Sigma_z$ = parameter to characterize dispersion in the z direction corrected for building wake effect (m); function of downwind distance x and atmospheric stability,
$H$ = effective height of release (m), usually taken as the physical release height for conservativeness in the absence of downwash effects; for ground level releases H=0,
$f(\Sigma_z, H, h_i)$ = capping inversion correction function,
$h_i$ = mixing layer height (m).

Note that effects of meandering, which is observed for stable atmospheres and low wind speeds and for only ground level releases (Snell and Jubach, 1981), are not considered in N288.2 (CSA, 1985) as part of the dispersion parameters used with the above equation. There, these effects are included through the assumption of uniform spread within a 22.5° sector used in the equation for prolonged- and long-term releases, under all weather conditions, and both for ground level as well as elevated releases.

A more extensive discussion of the methods of calculating dispersion and the meteorological input parameters required for these methods has been given in a recent report to AECB by Alp and Lewis (1985). The meteorological input parameters required for the above equation are

- S, atmospheric stability category (Pasquill class)
- $\bar{u}$, the transport wind speed (m/s)
- $\theta$, wind direction, required for determining the lateral distance of a receptor from the plume centreline aligned with the transport wind direction (radians, clockwise from North)
- $h_i$ , mixing layer height (m)

Specification of these meteorological parameters as a function of time over a release period constitutes the "weather scenarios" mentioned before. When onsite data are available for a suitable duration (e.g., a minimum of 1 year, although longer periods upto 3 or 5 years are usually recommended; see Alp and Lewis, 1985) the specification of these time series for safety analyses does not present a problem. However, when onsite data are not available, specification of these parameters is needed such that they would yield realistic but conservative dose estimates for design postulated accidents in safety analyses. We shall now describe the available offsite data that will be examined for deriving these realistic conservative weather senarios.

## 2. Determination of the Meteorological Input Parameters From Available Data

It was described in Chapter A that for the derivation of the realistic and conservative weather scenarios, an examination of available meteorological records from several sites for a suitable period would be required. The "suitable period" needs to be long enough so that year- to-year variability of weather would not introduce a bias into the derived weather scenarios. This implies that at least several years' data should be examined. The length of this period has been determined for the present project to be a minimum of 5 years. Details of this analysis are presented later in Chapter E.

In this section, the availability of long-term data required for determining the four input parameters (atmospheric stability, wind speed, wind direction, and mixing height) discussed in the previous section is presented together with the methods used in this project for obtaining these input parameters from the available data.

- Atmospheric Stability

There are several methods of determining atmospheric stability from meteorological observations, as was discussed in a recent Concord Scientific Corporation report to the AECB (Alp and Lewis, 1985). Of these methods, the only method for which long-term quality-controlled data are available is the Pasquill-Turner stability determination scheme (Pasquill, 1961; Turner, 1964). This scheme requires ground-level observations which are routinely available from first-order Atmospheric Environment Service (AES) weather stations, situated throughout Canada (see Chapter D). Hence, Pasquill-Turner stability classes are used in the present project as a means of characterizing atmospheric turbulence levels despite the well documented shortcomings of this scheme (e.g., Portelli 1976). These stability classes are commonly referred to as STAR (STability ARray) stabilities, after a computer program of the same name, developed for outline routine analysis of stability classes (see Martin and Tikvart, 1968). Concord's computer programs previously developed to handle such analyses were used for this project for the determination of STAR stabilities, using the ground-level data from the AES weather stations. These data are available in digital form in the AES Digital Archives.

There are 6 stability classes in the Pasquill-Turner scheme: Extremely Unstable (Class A), Moderately Unstable (Class B), Slightly Unstable (Class C), Neutral (Class D), Slightly Stable (Class E) and Stable (Class F). Other researchers have extended this scheme to include a 7th class, Extremely Stable (Class G), but only 6 classes were used for this project.

In order to determine the stability class, two main quantities must be known - net radiation at the ground and surface wind speed. The net radiation is dependent on four subsidiary variables:

(1) Time of day (i.e., day or night),
(2) Solar altitude,
(3) Cloud cover, and
(4) Ceiling height.

The detailed steps in determination of these variables are given below (see Wilkening and Ragland, 1979):

(i) If the total cloud cover is 10/10 (or 8/8) and the ceiling height is less than 7,000 feet, use net radiation index equal to 0 (whether day or night).
(ii) For night time (between sunset and sunrise)
  (a) If total cloud cover <4/10 (or <3/8), use net radiation index equal to -2.
  (b) If total cloud cover >4/10 (or >3/8), use net radiation index equal to -1.
(iii)For day time:
  (a) Determine the insolation class number as a function of solar altitude from Table B.1.
  (b) If total cloud cover <5/10 (or <4/8), use the net radiation index in Table B.2 corresponding to the insolation class number.
  (c) If cloud cover >5/10 (or >4/8), modify the insolation class number by the following six steps:

  (1) Ceiling <7,000 ft. Subtract 2
  (2) Ceiling >7,000 ft. but <16,000 ft. Subtract 1.
  (3) Total cloud cover equal 10/10 (or 8/8). Subtract 1 (This will only apply to ceilings >7,000 ft. since cases with 10/10 (8/8) coverage below 7,000 ft. are considered in item 1 above).
  (4) If insolation class number has not been modified by steps (1), (2) or (3) above, assume modified class number equal to insolation class number.
  (5) If modified insolation class number is less than 1, let it be equal to 1.

(6) Use the net radiation index in Table B.2 corresponding to the modified insolation class number.

If no information regarding ceiling is available, assume a ceiling between 7,000 and 16,000 ft. The solar altitude needed for use in Table B.1 was calculated by the basic earth-sun angular relationship equation (Duffie and Beckman, 1980):

$$\cos \theta = \cos (90-a) = \sin \sigma \sin \phi + \cos \sigma \cos \phi \cos w,$$

where $\theta_z$ is the zenith angle (angle between a beam from the sun and the straight overhead vertical - thus the zenith angle is always positive and between 0° and 90°),
$a$ is the solar altitude,
$\sigma$ is declination (angle between the sun at solar noon - solar noon is the highest position of the sun during the day and does not necessarily, and most often would not correspond to 1200 hours - and the plane of the equator) (north is positive) and corresponds to 23.45 sin (360 x $(\frac{284 + n}{365})$), where n is Julian day (1 through 365 or 366), $\sigma$ is declination in degrees,
$\phi$ is the latitude (positive if in northern hemisphere),
$w$ is hour angle (angle between position of the sun at solar noon and some other specified time - solar noon is 0 hour, each hour is 15° of longitude with morning defined negative and afternoon positive, e.g., $w=-15°$ for 1100 hours, $w=37.5°$ for 1430 hours).

The determination of day or night is carried out by comparing the given hour to the sunrise and sunset times. To find the set times the earth - sun angular equations are used and the Julian day, the latitude and longitude of the point of interest, and the standard meridian for the local time zone must be known. These are all easily found or calculated.

Once these various steps have been carried out to determine the net radiation index, the value of Pasquill stability class may be determined from a simple look-up table (Table B.2) if the 10-meter wind speed is also known. In this study, if the information of wind speed is missing, the stability of the hour was given a "F" stability in order to be in the conservative side.

- Wind Speed

Consistent with the reasoning for selecting the data base for atmospheric stability, wind speed data for this project were also taken from the AES digita archives. These winds are generally measured at a height of 10 m above the ground.

Five different wind speed classes were used in this work. Ranges of the wind covered by each class are given in Table B.3. These classes were determined on the basis that the concentration in a dispersing plume is inversely proportional to the wind speed as shown in Figure B.1. It is seen from the figure that the concentration drops rapidly as the wind speed increases. Therefore, class resolution is selected to be higher at the low wind speed range.

The representative wind speed for each class has been selected on the basis of being conservative for each wind speed class. Thus, the lower limit for each class is taken as the representative wind speed for that class. For the first class, for which the lower end (i.e., 0 m/s) would render the concentration formulas meaningless, the mid-range value is taken as representative.

It should be noted that, applicability of the Gaussian equation at this mid-range value (0.5 m/s) is somewhat questionable, and the model will tend to over-predict time integrated concentrations at low speeds. The rather arbitrary selection of this representative wind for the lowest wind speed class is done for the purpose of conservatism in this research study. Use of a more representative wind for this class which would lead to more representative concentrations as could be determined from models more suitable for low wind speeds, or use of an entirely different model for these speeds, should be investigated at a later date.

- Wind Direction

The wind direction data used in this project are also extracted from the AES Digital Archives for the reasons cited for atmospheric stability and wind speed.

The Digital Archive data are given in units of 10's of degrees, i.e., broken down into 36 classes. For the purpose of making the pattern analysis described in Chapter D of this report more practical, and consistent with general meteorological practice, these directions were assigned to 16 wind direction sectors (or classes) as shown in Table B.4. This will render the final weather scenarios somewhat more conservative if those scenarios are used with the short-term equation B.1 for long-term releases.

Note that in the archives a zero degree is assigned to a record when wind is very calm and the wind direction cannot be measured. Therefore, the zero degree has a different meaning from the 360 degree which indicates the North wind. In the present study, the "calm" case was treated as if the wind is blowing in the same direction as it was in the previous hour. The consequence of doing this is a slightly more conservative wind direction scenario.

- Mixing Layer Height

In general, the mixing layer height is not a commonly measured parameter at a surface weather station and therefore is not available in the AES Digital Archives. However, it can be related empirically to the STAR stability class. Therefore, for each hour when stability data are available the mixing height can be obtained as a dependent variable of the stability class. The mixing layer heights used in the present study for each season and stability class are shown in Table B.5 (Portelli, 1977; Busse and Zimmerman, 1973).

It should be noted that the effect of a capping inversion on the time integrated concentration as calculated by Equation B.1 is usually less than 5% for distances within 5 km of a 50 m release (Mourad, 1984). The effect is less for ground level releases. Therefore accurate specification of $h_i$ is not critical for our purposes. One exception could be in the case of lake-breeze or sea-breeze situations at coastal sites during warm spring or summer days where the height of the thermal internal boundary layer near the coast would be much less than the values given in Table B.5 (the boundary layer height would start at zero at the shore and grow approximately proportional to the square root of the distance from the shore (CSA, 1983; Raynor et al., 1980)). The number of hours in a year when such conditions may be expected is less than 10% (Portelli, 1985; Davis, 1985). Other exceptions could be nighttime neutral stability (D or 4) conditions, and during break-up of nocturnal inversions in early-morning hours. Lack of suitable data leads us to ignore these effects for the purposes of this study. It is recommended, however, that these effects be investigated later.

We shall now examine existing pattern analysis methods, for deriving "realistic conservative" weather scenarios from the meteorological data described above.

TABLE B.1: Insolation as a Function of Solar Altitude

| Solar Altitude (a) | Insolation | Insolation Class No. |
|---|---|---|
| 60° < a | Strong | 4 |
| 35° < a < 60° | Moderate | 3 |
| 15° < a < 35° | Slight | 2 |
| a < 15° | Weak | 1 |

TABLE B.2: Stability Class as a Function of Net Radiation Index and Wind Speed (Pasquill Class A = 1, F = 6, etc.)

| Wind Speed | | Net Radiation Index | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Knots | (m/sec) | 4 | 3 | 2 | 1 | 0 | -1 | -2 |
| 0.1 | (0.05) | 1 | 1 | 2 | 3 | 4 | 6 | 6 |
| 2.3 | (1.18) | 1 | 2 | 2 | 3 | 4 | 6 | 6 |
| 4.5 | (2.31) | 1 | 2 | 3 | 4 | 4 | 5 | 6 |
| 6 | (3.09) | 2 | 2 | 3 | 4 | 4 | 5 | 6 |
| 7 | (3.60) | 2 | 2 | 3 | 4 | 4 | 4 | 5 |
| 8.9 | (4.58) | 3 | 3 | 4 | 4 | 4 | 4 | 5 |
| 10 | (5.14) | 3 | 3 | 4 | 4 | 4 | 4 | 5 |
| 11 | (5.66) | 3 | 3 | 4 | 4 | 4 | 4 | 4 |
| >12 | (6.17) | 3 | 4 | 4 | 4 | 4 | 4 | 4 |

TABLE B.3: The Ranges of the Wind Speed At Each Wind Speed Class

| Wind Speed Class | Ranges of the Wind Speed (m/sec) | Representative Wind Speed (m/sec) |
|---|---|---|
| 1 | $u < 1$ or $u$ is missing | 0.5 |
| 2 | $1 < u < 2$ | 1 |
| 3 | $2 < u < 4$ | 2 |
| 4 | $4 < u < 8$ | 4 |
| 5 | $u > 8$ | 8 |

TABLE B.4: Assignment of Wind Direction Data to Wind Direction Sectors

| Direction Sector | Direction (10's of Degrees) |
|---|---|
| 1 | 35-1 |
| 2 | 2-3 |
| 3 | 4-5 |
| 4 | 6-7 |
| 5 | 8-10 |
| 6 | 11-12 |
| 7 | 13-14 |
| 8 | 15-16 |
| 9 | 17-19 |
| 10 | 20-21 |
| 11 | 22-23 |
| 12 | 24-25 |
| 13 | 26-28 |
| 14 | 29-30 |
| 15 | 31-32 |
| 16 | 33-34 |

TABLE B.5: Mixing Layer Height * (m)

| Stability Class | | Season | | | | |
|---|---|---|---|---|---|---|
| | | Spring | Summer | Fall | Winter | Annual |
| A | 1 | 1650 | 1950 | 1350 | 900 | 1500 |
| B | 2 | 1100 | 1300 | 900 | 600 | 1000 |
| C | 3 | 1100 | 1300 | 900 | 600 | 1000 |
| D | 4 | 1100 | 1300 | 900 | 600 | 1000 |
| E | 5 | 100 | 100 | 100 | 100 | 100 |
| F | 6 | 100 | 100 | 100 | 100 | 100 |

| | |
|---|---|
| Spring: | March, April, May |
| Summer: | June, July, August |
| Fall: | September, October, November |
| Winter: | December, January, February |

*In the case of lake-breeze and sea-breeze situations at coastal sites during warm spring or summer days (< 10 % of the available hours in a year), a thermal internal boundary layer would develop. Its height would be zero at the shore and grow approximately proportional to the square root of the distance from the shore.

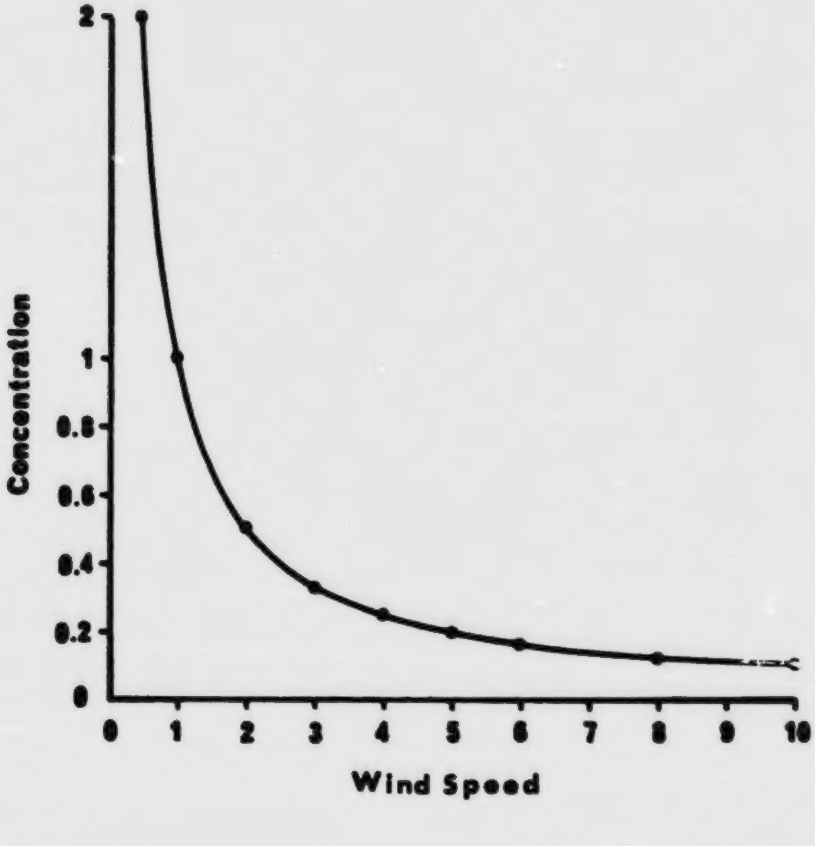

Figure B.1: The Relation Between the Time Integrated Concentration and the Wind Speed

## C. LITERATURE SURVEY FOR "REALISTIC CONSERVATIVE" WEATHER SCENARIOS

The methods used in this study for searching relevant publications and the findings of the survey are discussed in this section.

### 1. Methods Used in the Literature Search

A review of the published international literature dealing with meteorological aspects of nuclear power plant siting and safety was conducted by searching computerized bibliographic information files and hard-copy sources. The purpose of the search was to identify the manner in which other countries specify weather scenarios or conditions that would be used in safety analyses related to short-, prolonged- and long-term accidental releases, when onsite meteorological data of suitable duration are not available.

Online bibliographic files selected for searching were chosen on the basis of their subject coverage; the three files selected were INIS (International Nuclear Information Service), NTIS (National Technical Information Services), and Meteorological and Geoastrophysical Abstracts.

The INIS file, available through CAN/OLE (Canadian Online Enquiry), is produced by the International Atomic Energy Agency, Vienna. Covering the time span from 1970 to the present, this computer database contains approximately 550,000 entries, with a growth rate of 75,000 document reference entries per year. The INIS file provides extensive coverage of publicly available documents in the subject area of nuclear science and technology; forty to fifty co-operating countries input documentation published within their national boundaries. Access to the file's contents is aided by the INIS Thesaurus, a controlled vocabulary structure designed to eliminate nomenclature ambiguity and facilitate use of preferred terms. The INIS Thesaurus was used when compiling the Boolean logic terms for the search.

The NTIS file, available through DIALOG, was also searched. This file consists of over one million records of U.S. government-sponsored technical research in various fields (including the nuclear field) by federal agencies, their contractors or granters. Retrospective coverage to 1964 is provided by this file.

In addition, the Meteorological and Geoastrophysical Abstracts file (also available through DIALOG) was accessed. This file, spanning the period from 1972 to the present, is produced by the American Meteorological Society. Coverage of over 200 sources, including technical journals, monographs, proceedings, reviews and annual publications, has provided a file of over 98,000 records.

Manual searching of hard-copy sources was also conducted, using published bibliographies from various agencies, including the U.S. Nuclear Regulatory Commission and relevant library holdings.

The scope of retrieval was limited to publications in the official languages of Canada, and in some cases, in German.

## 2. Results of the Literature Survey

A complete bibliography of the literature screened in the present study for "realistic conservative" scenarios for safety analyses of nuclear facilities is given in Appendix A1.

The screening indicated that very little has been done on specifying weather scenarios for dose calculations with incomplete meteorological data.

In Canada, conservative weather conditions were first specified by Hurst and Boyd (1972), as was discussed in Chapter A of this report. The more recent draft AECB Staff Position paper (1982) proposes a more balanced "mix" of weather conditions to be used as realistic conservative scenarios, and it is these scenarios that are being considered in the present study for substantiation or modification.

In the U.K., the National Wind Rose Data representing average conditions are used when there are no onsite meteorological data (Koronasiewics, 1984). The data used in a recent document on the derivation of frequency/release limit criteria for siting of nuclear installations (Nair and Macdonald, 1981) is shown in Table C.1. Clearly, such an approach is not suitable for the purposes of the present project.

In 1974, U.S. Atomic Energy Commission published 3 regulatory guides, 1.3, 1.4, and 1.5 (U.S. NRC, 1974). In these guides, the conservative weather scenarios were specified very clearly. However, through private communication (Spickler, 1984), it was found that these guides were no longer used. The present regulation is that at least one year of onsite meteorological data are required in order to apply for construction licensing (Regulatory Guide 1.145, 1983).

In view of this sparsity of information from international literature, a pattern analysis method was designed for this project. A general description of this method will be presented in Chapter E using results from a selected site, following the site selection process which is described in the next chapter.

TABLE C.1: Annual U.K. Average Meteorological Data

| Pasquill Stability Class | Wind Speed (m/s) | Weather Category Joint Probability (%) |
|---|---|---|
| A | 1 | 0.78 |
| B | 2 | 5.23 |
| C | 5 | 15.55 |
| D | 5 | 64.78 |
| E | 3 | 5.90 |
| F | 2 | 5.77 |
| G | 2 | 2.04 |

## D. SITE SELECTION

Derivation of realistic conservative weather scenarios that would be used in safety analyses requires the examination of available meteorological data for suitably selected sites. Site selection has been guided by consideration of the synoptic and mesoscale characteristics of existing Canadian nuclear power facilities and availability of long term data on the AES Digital Archives.

### 1. Synoptic and Mesoscale Regions of Interest

Figure D.1 shows the synoptic-scale air pollution potential regions for Canada, where air pollution potential is determined by such measures of the dispersive and cleansing capability of the lower atmosphere as average mixing layer height, mean transport wind speed, average ventilation coefficient, low-level inversion frequency, and low wind-speed frequency (see, e.g., Portelli, 1977).

All of Canada's nuclear generating stations lie in the Great Lakes region (region 5 of Figure D.1) except for Point Lepreau, New Brunswick, which is located in the Atlantic region (region 7). The Great Lakes region is an interior modified continental region (e.g., Wilson, 1979) with respect to climate, part of a broad and generally flat corridor extending from the Arctic Ocean through central Canada and the central United States to the Gulf of Mexico. This area is located along the main Northern Hemisphere mid-latitude storm track, and local weather is characterized by the passages of an unending succession of anticyclonic and cyclonic weather systems. The presence of large open bodies of water, i.e., the five Great Lakes, serves to moderate the extremes of climate experienced here compared to the central plains to the west, and also gives rise to mesoscale land- and lake-breeze circulations along the lakeshores.

The Atlantic region is a maritime region which borders the Atlantic Ocean, a salt-water body which rarely freezes in the winter, with the exception of the Labrador coast to the north of Newfoundland and the Gulf of St. Lawrence. The fall and winter months in the Atlantic region are generally accompanied by extensive cloud and precipitation. Fog, stratus cloud, and a stable surface layer are common in coastal areas in the summertime due to the frequent presence of an offshore high-pressure cell. The influence of frequent cold stable winds from the west in the winter and cold offshore water in the summer results in a high air pollution potential and reduced dispersive capability for this region.

In order to account for differences due to individual site characteristics, three mesoscale sub-regions have been identified within these two synoptic regions: lakeside, riverside, and oceanside. The Ontario Hydro sites at Bruce, Pickering, and Darlington represent lakeside locations, the Hydro Québec site at Gentilly on the St. Lawrence River represents a riverside location, and the New Brunswick Electric Power Commission site at Point Lepreau represents an oceanside location.

### 2. Available Surface Meteorological Data Near the Sites of Interest

The meteorological quantities required for this study were identified in Chapter B of this report.

As was discussed in that section, the primary source of meteorological data in Canada is the network of observing stations operated by Environment Canada's Atmospheric Environment Service (AES). A number of AES stations are located near Canadian nuclear power plants. Tables D.1 to D.4 list the data available for AES surface observing stations located at or near Bruce, Pickering and Darlington, Gentilly, and Point Lepreau, respectively (from AES, 1977a,b, 1981a,b,c). Figures D.2 to D.5 show the locations of the various meteorological stations relative to the nuclear generating station sites.

Recommendations for three representative meteorological stations to be used in the weather scenario analysis and the rationale for their selection will now be presented.

None of the three lakeside generating station sites - Bruce, Pickering and Darlington - has an onsite surface meteorological station with a suitably long period of hourly observations. Although some wind observations have been taken onsite at Bruce and Douglas Point, the nearest station which takes regular hourly observations is Wiarton Airport, located about 60 km to the northeast (see Table D.1 and Figure D.2) at the head of Colpoys Bay on the east side of the Bruce Peninsula. Because it is on the opposite side of the peninsula, the meteorological measurements from this airport will not be representative. An automatic meteorological station is presently sited at Goderich Municipal Airport, about 65 km south-southwest of Bruce on Lake Huron. Although this automatic station takes hourly meteorological measurements, it does not measure cloud height, one of the quantities needed for STAR stability calculations.

For Pickering and Darlington, the most representative hourly station with adequate coverage is Trenton Airport (see Table D.2 and Figure D.3). The Downsview Airport station in Toronto is closer to both sites but is situated 15 km inland. The automatic meteorological stations at Cobourg and Toronto Island suffer from the same disadvantage as the one at Goderich. Consequently, Trenton Airport was selected as the best lakeside meteorological station to represent a lakeside generating site.

From an examination of Figure D.4 and Table D.3, it is apparent that the nearest regular hourly observing station to Gentilly is Québec Airport, located about 100 km to the northeast on the north shore of the St. Lawrence River. Hourly meteorological observations used to be taken at Trois-Rivières Airport, but only during airport hours. Hence, Quebec Airport was selected as the representative riverside meteorological station for Gentilly.

Point Lepreau Nuclear Generating Station suffers from a similar paucity of nearby meteorological stations. From an examination of Table D.4 and Figure D.5, the most representative oceanside meteorological station will be Saint John Airport. Data from this station were also used in an environmental assessment for Point Lepreau (NBEPC, 1977).

TABLE D.1: Available Data at AES Meteorological Stations Located Near Bruce Nuclear Generating Station (44°20'N, 81°35'W)

| Station ID | Station Name | Station Location | Distance | Period of Record for Hourly Meteorological Measurements |
|---|---|---|---|---|
| 61210K7 | Bruce Ontario Hydro | (44°20'N, 81°35'W, 180 m) | onsite | 1971/08 - 1976/08+ |
| 6122078 | Douglas Point | (44°20'N, 81°36'W, 180 m) | onsite | 1961/06 - 1961/09<br>1962/05 - 1962/08 |
| 6122079 | Douglas Point | (44°20'N, 81°36'W, 180 m) | onsite | 1961/06 - 1963/08+<br>1965/10 - 1971/07+ |
| 6126210 | Paisley | (44°16'N, 81°22'W, 251 m) | 23 km | 1965/05 - present+ |
| 6127887 | Southampton | (44°30'N, 81°21'W, 186 m) | 25 km | 1954/12 - 1973/10+ |
| 6127895 | Southampton Tomori | (44°30'N, 81°19'W, 213 m) | 25 km | 1973/11 - present+ |
| 6122846 | Goderich A | (43°46'N, 81°42'W, 213 m) | 65 km | 1969/12 - 1970/12*<br>1971/05 - 1973/07*<br>1973/08 - 1974/12* |
| 6122849 | Goderich Municipal A | (43°46'N, 81°42'W, 213 m) | 65 km | 1975/01 - 1980/10* |
| 6122847 | Goderich (Aut.) | (43°46'N, 81°43'W, 217 m) | 65 km | 1980/11 - present** |
| 6119500 | Wiarton Airport | (44°45'N, 81°06'W, 222 m) | 65 km | 1947/07 - present |

+Surface wind speed and direction only

*Irregular observations

**Does not measure cloud height or visibility

TABLE D.2: Available Data at AES Meteorological Stations Located Near Pickering (43°48'N, 79°03'W) and Darlington (43°52'N, 78°43'W) Generating Stations

| Station ID | Station Name | Station Location | Distance⁺ | Period of Record for Hourly Meteorological Measurements |
|---|---|---|---|---|
| 6151968 | Darlington (Aut.) | (43°52'N, 78°47'W, 93 m) | 28 km/ onsite | 1972/04 - 1974/11** |
| 6151684 | Cobourg (Aut.) | (43°57'N, 78°10'W, 77 m) | 72/45 km | 1975/07 - present** |
| 6158875 | Trenton Airport | (44°07'N, 77°32'W, 86 m) | 122/95 km | 1944/07 - present |
| 6166418 | Peterborough A | (44°14'N, 78°21'W, 191 m) | 81/59 km | 1971/07 - 1973/06*<br>1973/07 - present* |
| 6158665 | Toronto Island A | (43°38'N, 79°24'W, 77 m) | 35/60 km | 1965/10 - 1972/12*<br>1973/01 - present* |
| 6158666 | Toronto Island A (Aut.) | (43°38'N, 79°24'W, 81 m) | 35/60 km | 1972/04 - present** |
| 6158655 | Toronto Int'l. A | (43°40'N, 79°38'W, 173 m) | 48/74 km | 1964/04 - present |
| 6158443 | Toronto Downsview A | (43°45'N, 79°29'W, 198 m) | 34/62 km | 1956/10 - 1965/06<br>1965/07 - present* |

⁺(from Pickering/ from Darlington)

*Irregular observations

**Does not measure cloud height or visibility

TABLE D.3: Available Data at AES Meteorological Stations Located Near Gentilly Generating Station (46°22'N, 72°20'W)

| Station ID | Station Name | Station Location | Distance | Period of Record for Hourly Meteorological Measurements |
|---|---|---|---|---|
| 7018563 | Trois-Rivières A | (46°21'N, 72°41'W, 57 m) | 15 km | 1963/09 - 1977/06* |
| 7013362 | Joliette Ville | (46°01'N, 73°27'W, 58 m) | 100 km | 1967/04 - 1971/07$^{+}$<br>1972/04 - 1974/10$^{+}$<br>1975/05 - 1977/12$^{+}$ |
| 7016294 | Québec Airport | (46°48'N, 71°23'W, 73 m) | 98 km | 1957/01 - present |
| 7025250 | Montréal Int'l. A | (45°28'N, 73°45'W, 36 m) | 174 km | 1957/01 - present |
| 7027320 | St. Hubert A | (45°31'N, 73°25'W, 27 m) | 137 km | 1938/08 - present |

$^{+}$Surface windspeed and direction only
*Irregular observations

TABLE D.4: Available Data at AES Meteorological Stations Located Near Point Lepreau (45°03'N, 66°27'W) Generating Station

| Station ID | Station Name | Station Location | Distance | Period of Record for Hourly Meteorological Measurements |
|---|---|---|---|---|
| 8104937 | St. Stephen (Aut.) | (45°12'N, 67°15'W, 26 m) | 65 km | 1976/12 - present** |
| 8104900 | Saint John A | (45°19'N, 65°53'W, 109 m) | 56 km | 1952/01 - present |
| 8104925 | Saint John Red Head | (45°15'N, 66°01'W, 26 m) | 41 km | 1964/09 - 1967/06+<br>1971/06 - 1972/11+ |
| 8101500 | Fredericton A | (45°52'N, 66°32'W, 20 m) | 88 km | 1951/04 - present |

+Surface windspeed and direction only

**Does not measure cloud height or visibility

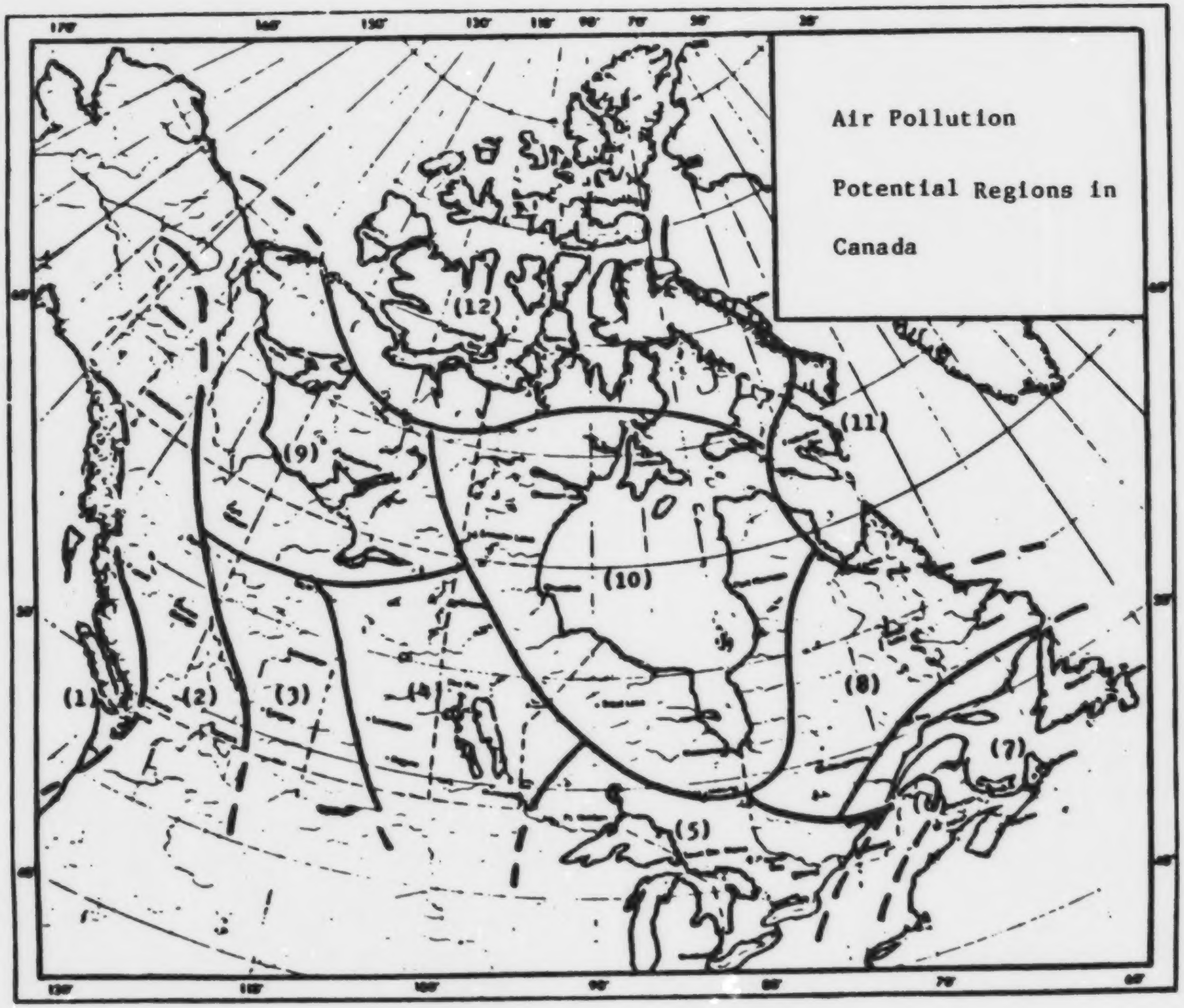
Air Pollution
Potential Regions in
Canada
(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
(10)
(11)
(12)

FIGURE D.1: Air Pollution Potential Regions for Canada (from Wilson, 1979)

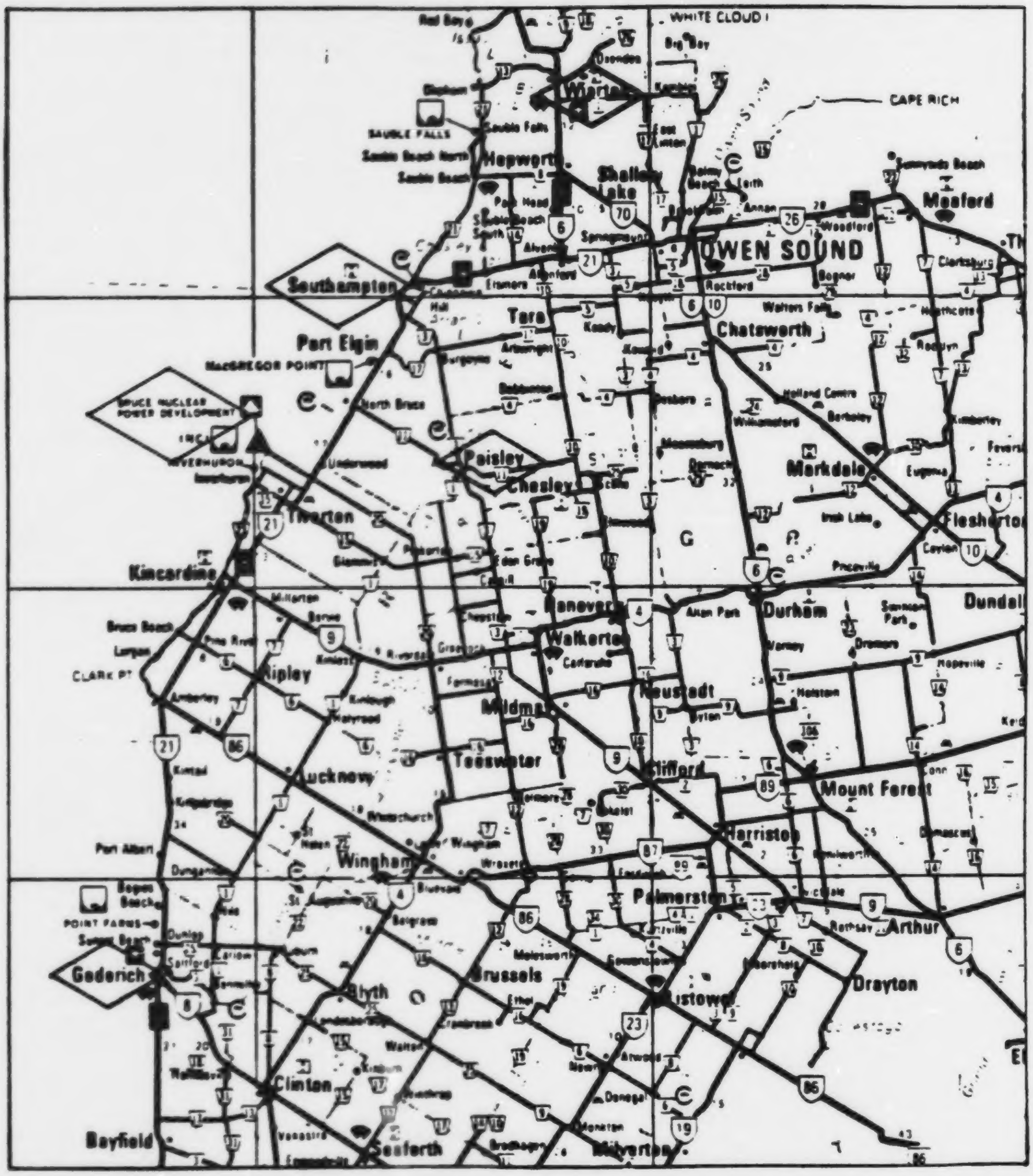
WHITE CLOUD I
CAPE RICH
SAUBLE FALLS
Hepworth
Shallow Lake
OWEN SOUND
Meaford
Southampton
Port Elgin
Tara
Chatsworth
MacGREGOR POINT
BRUCE NUCLEAR POWER DEVELOPMENT
INVERHURON
Paisley
Chesley
Markdale
Flesherton
Tiverton
Kincardine
Hanover
Durham
Dundalk
Walkerton
Ripley
CLARK PT
Neustadt
Mildmay
Teeswater
Lucknow
Clifford
Mount Forest
Harriston
Wingham
Palmerston
Arthur
POINT FARMS
Goderich
Brussels
Listowel
Drayton
Blyth
Clinton
Bayfield
Seaforth
Milverton

Figure D.2: AES Surface Meteorological Stations Located Near Ontario Hydro Bruce Site. The Bruce site is marked by a solid black triangle. The locations of Goderich, Paisley, and Southampton are indicated by diamonds. Douglas Point is located on the Bruce Site. (Scale; 1:800,000)

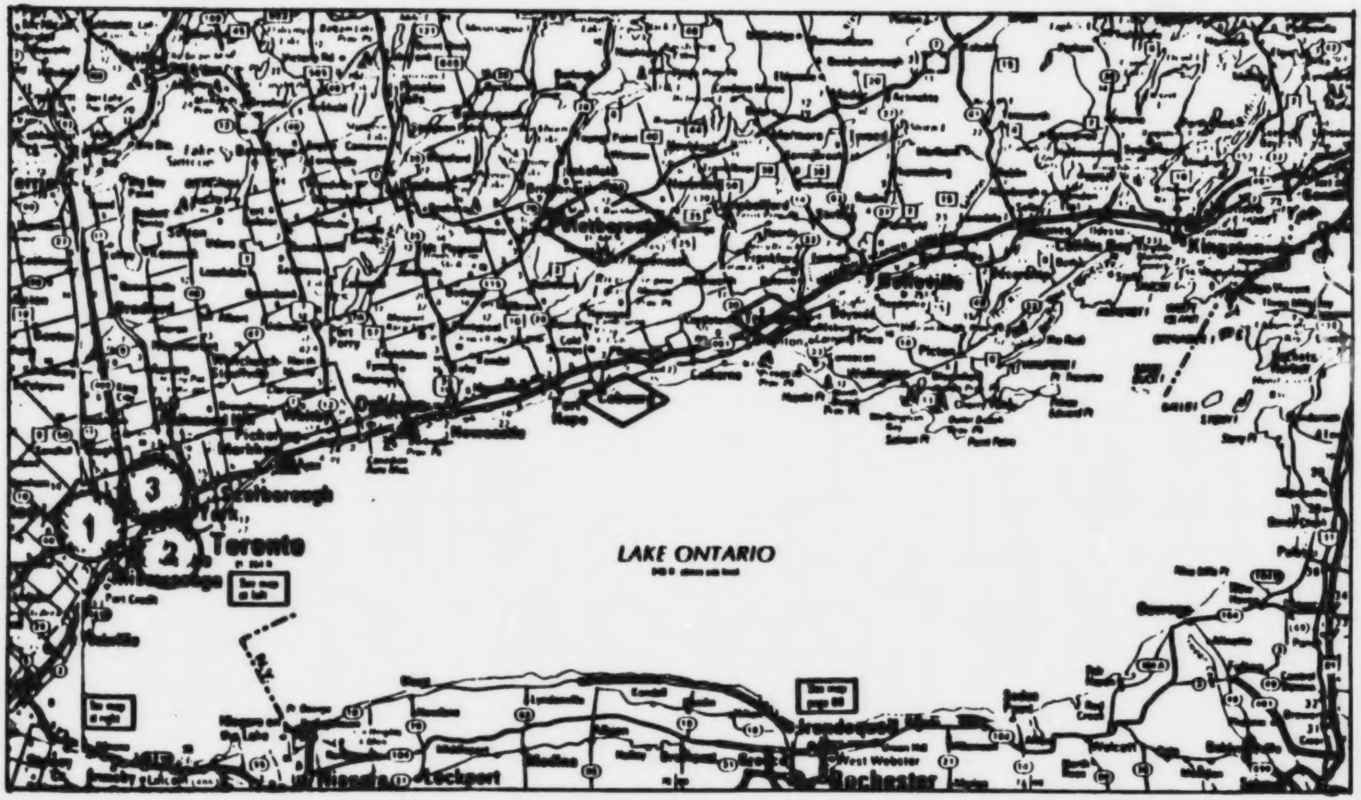
LAKE ONTARIO
1
2
3
Toronto
Scarborough
Kingston
Rochester
West Webster
Lockport

Figure D.3: AES Surface Meteorological Stations Located Near Ontario Hydro Pickering and Darlington Sites. The two nuclear station sites are marked by solid black triangles. The locations of meteorological stations at Toronto International Airport (1), Toronto Island Airport (2), and Toronto Downsview Airport (3) are marked by circles. Peterborough, Cobourg, and Trenton stations are indicated by diamonds. (Scale, 1:1,500,000)

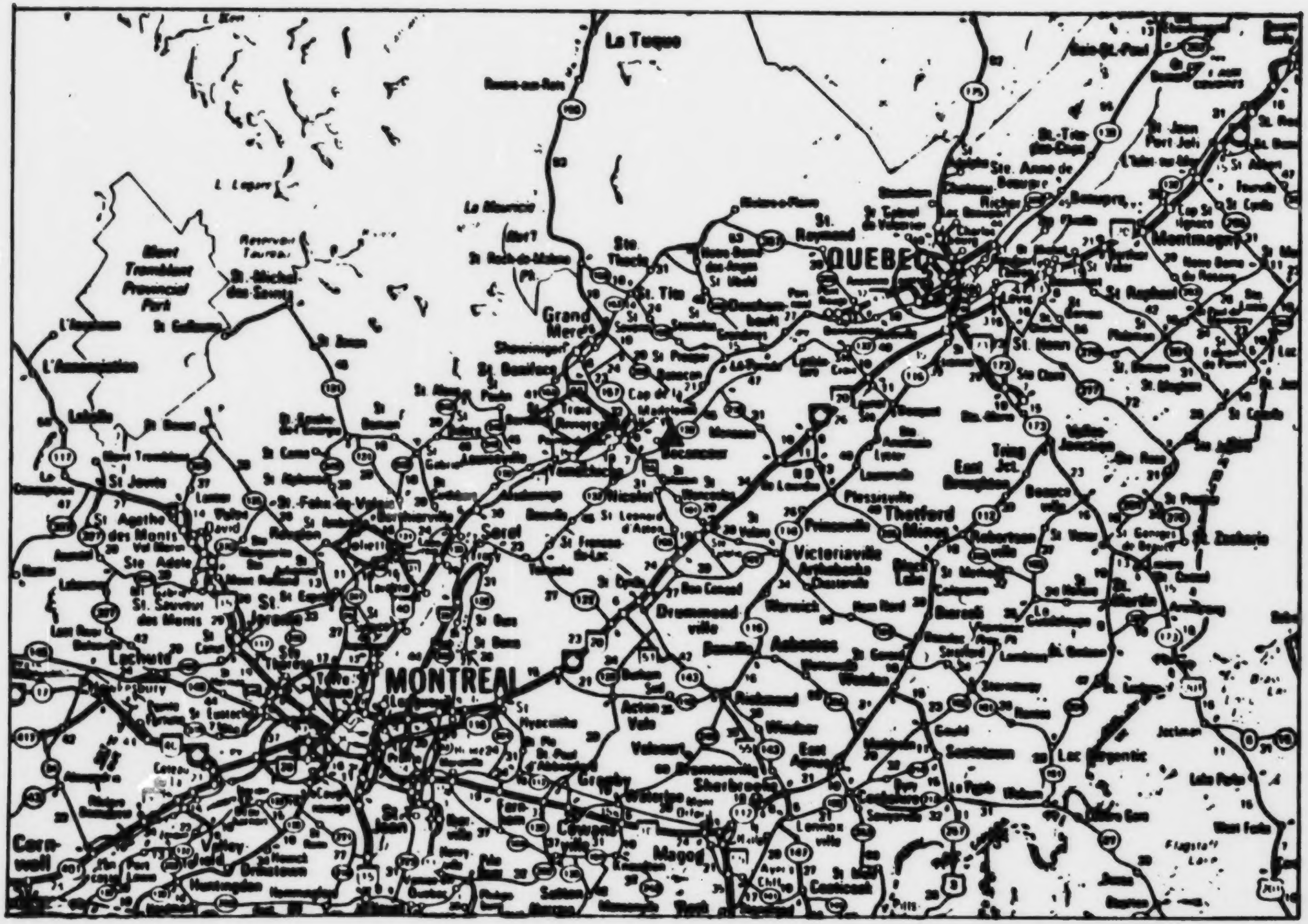
La Tuque
QUEBEC
MONTREAL
Grand Mere
Sorel
Thetford Mines
Victoriaville
Drummondville
Asbestos
Sherbrooke
Magog
Granby
Lachute
Cornwall
Mont Tremblant Provincial Park
Montmagny

Figure D.4: AES Surface Meteorological Stations Located Near Hydro Quebec Gentilly site. The Gentilly station site is marked by a solid black triangle. Montreal International Airport at Dorval (1), St. Hubert Airport (2), and Quebec Airport (3) are indicated by circles. The locations of Joliette Ville and Trois Rivieres stations are marked by diamonds. (Scale; 1:2,200,000)

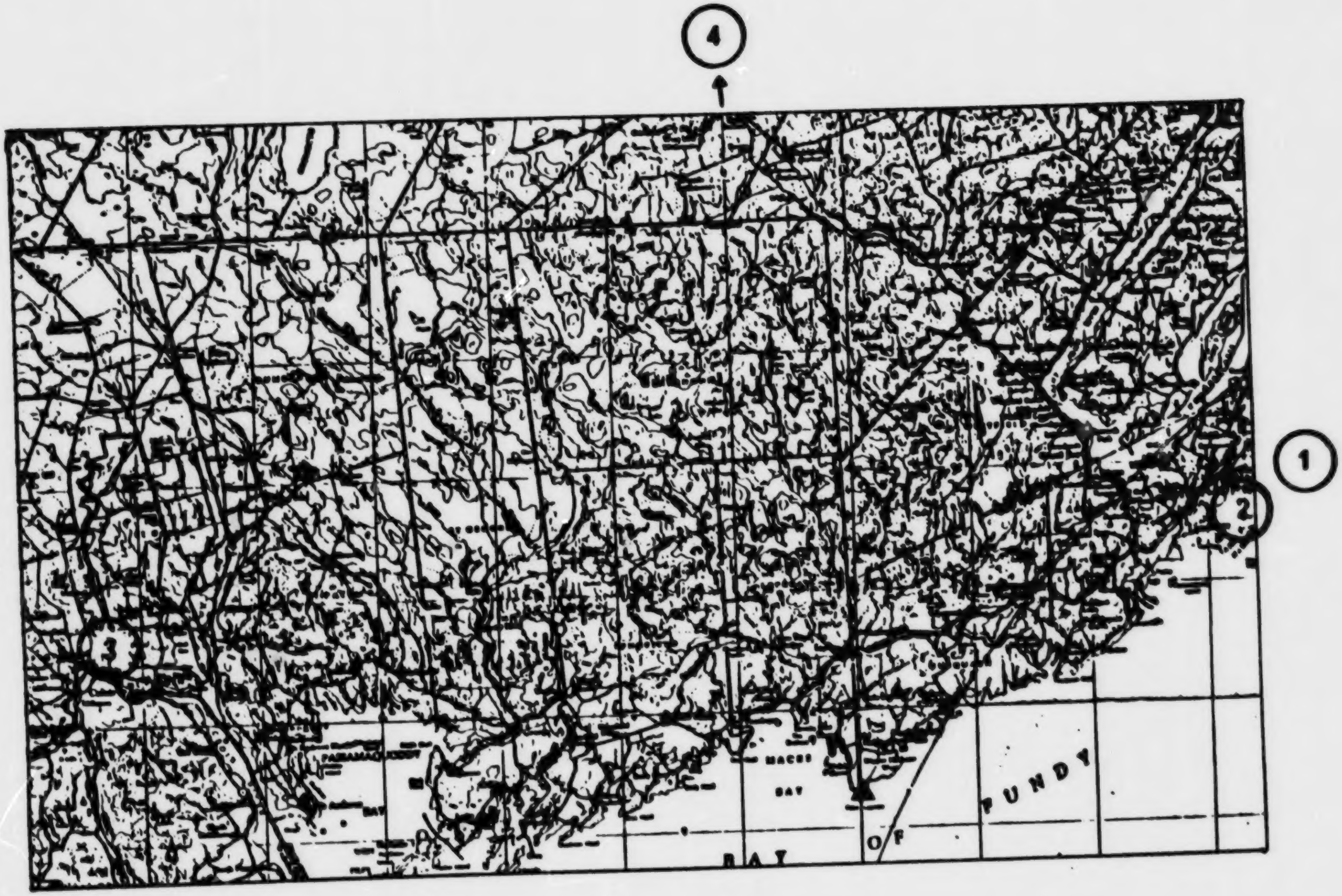
4
1
2
3
MACES BAY
BAY OF FUNDY
PASSAMAQUODDY

Figure D.5: AES Surface Meteorological Stations Located Near Point Lepreau, New Brunswick. Point Lepreau is marked with a solid black triangle. Saint John Airport (1), Saint John Red Head (2), and St. Stephen (3) are marked by circles. Fredericton Airport (4) lies 88 km to the north as indicated by arrow at top of map. (Scale, 1:500,000)

## E. PRESENT METHOD FOR DERIVING "REALISTIC CONSERVATIVE" WEATHER SCENARIOS FROM METEOROLOGICAL DATA

Four meteorological parameters have been identified in Chapter B as the parameters that need to be specified in a time series form for the duration of an accidental release. The release durations of interest are from a few minutes to about thirty days (720 hours). At the beginning of a release, a certain combination of the four meteorological parameters will exist. Let us call this combination the start condition. The basic approach taken in this project to recognise repeating patterns after the "start condition" is to examine observed meteorological data for lag correlations between the start condition and subsequent atmospheric conditions days and weeks later. What must be examined is not the probability of a certain weather event occurring, as would be the case for a release of short duration, but rather the probability of a **sequence** of weather events occurring. Since it is difficult to examine the probability of actual sequences, the present approach is to examine the probability of a certain weather event occurring given that one particular event (start condition) happened at a particular time in the past. If the frequency of occurrence of each combination of the four parameters at each hour after the start condition is determined for a number of sites with varying meteorological characteristics, then it will be possible to derive a general scenario which would yield realistic and conservative estimates of time integrated concentration which will not be exceeded more than 10% of the time using real data from those sites.

The method developed in this project for determining first the frequency of occurrence of each combination of the four parameters at each hour after the start condition, and second the realistic conservative scenario corresponding to the period of data considered, is described in this section.

The four meteorological parameters of interest as identified in Chapter B are:

- stability,
- wind speed,
- wind direction, and
- mixing layer height.

Since mixing layer height has been specified as a function of stability (Chapter B), there are only three independent parameters to consider in the analyses.

There are six stability, five wind speed, and sixteen wind direction classes considered in this study (Chapter B). These lead to 6x5x16 = 480 combinations or categories of weather that need to be analyzed, i.e., for any of these weather categories taken as a "start condition," we need to determine the frequency of occurrence of each of the 480 weather categories at each hour after the start condition, up to 720 hours, and then analyze the patterns. Clearly, this is not very practical due to very large computer time requirements, and is not necessary for present purposes. Since wind direction is only required to determine the relative position of a plume with respect to a receptor, the three independent parameters of interest will be grouped into two:

- stability and wind speed,
- wind direction,

and their patterns will be analyzed separately to form separate scenarios for the two groups. The stability-wind speed and wind direction scenarios will then be combined. Note that this will lead to more conservative scenarios than if the analysis is done on all three parameters simultaneously.

## 1. Pattern Analysis for the Stability-Wind Speed Group

The pattern of joint frequency of occurrence of each stability-wind speed combination is determined as described below. In the discussion, each combination of these two parameters will be denoted by "condition ij," where i is for stability, i = 1,2,...,6 (corresponding to the six STAR stability classes given in Table B.2), and j is for wind speed class as defined in Table B.3, j = 1,2,...,5. Altogether there are 30 combinations or "weather conditions." A "61 condition" denotes the combined occurrence of the 6th stability class with the 1st wind speed class. Note that not all of these 30 weather conditions occur in reality with the stability classification scheme used here. These conditions will be evident later and have no effect on the pattern analysis.

### 1.1 Stability-Wind Speed Conditions and Their "Conservativeness"

In anticipation of the ensuing pattern analysis we shall first rank the 30 atmospheric conditions in terms of their conservativeness, i.e., in terms of how high a time integrated concentration they would yield for a unit release.

The "conservativeness" of a given atmospheric condition is determined by calculating the time integrated concentration $\chi$ for a single unit release using Equation B.1. For ground level releases, the relative conservativeness of the atmospheric conditions will not change with distance x from source, and this ranking can be accomplished calculating $\chi$ at any x. However, for elevated releases, the relative conservativeness of the atmospheric conditions will change as a function of x (see the discussion in Chapter A of this report and also the proposed scenarios in the AECB draft Position Paper, AECB, 1982) as well as a function of release height. A release height of H = 50 m which provides an upper limit to expected release heights for a CANDU reactor, is considered in the present study. Three horizontal downwind distances are considered for this release height. These are x = 1 km, 3 km, and 5 km. .

The relative rankings of the 30 atmospheric conditions and the associated $\chi$ values are presented in Table E.1. The $\chi$ values were calculated based on Equation B.1, using the following parameters. Unit release in a period of one hour is assumed. Winter values for the mixing layer height have been used. For ground level releases, building wake effects were included, and a representative building wake cross section of 1500 $m^2$ was used. For elevated releases building wake effects were not included. Surface roughness was taken that corresponding to grass covered terrain which will probably be on the conservative side for most sites since there will be trees and other buildings in the vicinity.

The rankings for the elevated release are the most different from the ground-level release at the distance closest to the source, i.e., at x = 1 km. As we move away from the source, the rankings become progressively more similar to the ground level release. Hence any weather scenario for distances beyond x = 5 km will be very similar to the scenario for the ground-level release. Therefore distances beyond 5 km are not considered separately.

The effect of building wakes could change the rankings for elevated releases. Due to time and budget limitations, these effects were not examined in the present project.

Inclusion of the effect of meandering could change the rankings for ground level releases. However, it is difficult to include this effect in the pattern analysis method, and therefore it was included in the final weather scenarios in a rather intuitive manner. The effect of including it throughout the analysis needs to be further investigated.

The rankings could also be different if they were based on dose considerations rather than on time-integrated concentrations.

### 1.2 Frequency of Occurrence of Weather Conditions During the Period After A Given "Start Condition"

A release can start occurring during any arbitrary atmospheric condition. For a given start condition, this start condition is first located in the available time series of meteorological data, and the frequency of occurrence of each weather condition in the next 720 hours are determined and tabulated in a 30 x 720 matrix. Here, '30' represents the 30 different combinations of atmospheric conditions (6 stability classes and 5 wind speed classes) and '720' represents the 720 consecutive hours (30 days) following the first hour of occurrence. After this is completed, the next occurrence of the "start condition" in the available data is located and the atmospheric conditions for the following 720 hours are added to their respective positions in the same 30 x 720 matrix. The above procedure is repeated until the end of the available data (e.g., five years). The result of this exercise is a table which gives the frequency of occurrence of each of the 30 combinations of stability-wind speed at each hour with a given "start condition." An example of such a table containing the first 72 hours after a start condition of "61" is given in Tables E.2a and E.2b.

Table E.2a shows the number of hourly occurrences of each atmospheric condition for the 72 hours following a "61" start condition. For example, in the 5 years of data under consideration here, out of the 3578 occurrences (not shown on the table) of a "61" start condition, 2440 of them have been followed by another "61" condition in the first hour after the initial hour, 2025 of them have been followed by a "61" condition in the second hour, etc. Note that, the latter is not the probability that 3 consecutive "61" hours have occurred. Table E.2b presents the same information but in terms of percentages rather than hourly occurrences. For example, there is a 68.2% (2440/3578) chance that a "61" condition will occur in the first hour after an initial occurrence of a "61" condition.

In these tables, it is to noted that some conditions do not occur at all, which is as a result of the relationship between stability and wind speed used in the STAR method (Table B.2). For example, a "51" combination (i.e., stability = 5, windspeed < 1m/s) cannot occur according to the specifications in that table. Also note the diurnal pattern (oscillation with a 24-hour period) for each atmospheric condition.

The second step in the analysis is to arrange the columns in the table such that the 30 atmospheric conditions are ranked in the order of their "conservativeness," decreasing from left to right. Note that this has already been done in Tables E.2a and E.2b. Tables E.3-E.5 present the same information, but ranked according to the rankings required for the elevated release for three different downwind distances (see Table E.1).

The information in, for example, Table E.2b can be used for determining a 72-hour weather scenario in the following manner. If, for example, a "worst case" scenario is required, i.e., it is demanded that each hour is made up of the worst possible weather condition, then the scenario would consist of 72 consecutive 61 conditions since there is a finite chance that this condition would occur at any hour after the given start condition. The corresponding time integrated concentration will then be the maximum possible and will never be exceeded, i.e., exceeded only 0% of the time. However, according to our criterion for defining a realistic and conservative scenario (Chapter A) we want the time integrated concentration not to be exceeded more than 10% of the time out of the possible time integrated concentrations for the 72-hour scenarios. We can accomplish this by specifying a certain percentage criterion, such that when the atmospheric condition that causes the cumulative percentage frequency of occurrence of the more conservative conditions (i.e., when added together from left to right) to exceed this percentage criterion is selected as the atmospheric condition for that hour, the 72 consecutive conditions thus selected for 72 consecutive hours would yield a time integrated concentration that would not be exceeded more than 10% of the time. Clearly, specification of this percentage criterion will require some trial and error. The method for deriving the percentage criterion will be described in detail in Section 1.4. Before we can derive this percentage criterion for various release durations, we need to calculate the time integrated concentrations $\chi_{10-t}$ for each release duration t that will be used as the critical limit that should not be exceeded more than 10% of the time.

Since there are 30 possible start conditions, 30 separate tables, one for each start condition, will be required for a systematic survey. However, if selection of only one start condition, is acceptable, then only one table would be required. We shall return to this point later and show that a single worst case start condition can be justified based on comparisons of scenarios with various start conditions.

## 1.3 Calculation of $\chi_{10}$ for Various Release Durations

The third step in the analysis is to calculate $\chi_{10-t}$, the time integrated concentration that will not be exceeded more than 10% of the time for a given release duration t, using the full data set under examination (see Chapter A of this report and AECB, 1982). The full data set in our example is 5 year data from St. John airport. The release scenario used is unit release every hour throughout the release duration. The release durations considered in the present study are:

- 1 hr,
- 4 hrs,
- 8 hrs,
- 24 hrs,
- 72 hrs,
- 240 hrs,
- 720 hrs.

First of all, the time integrated concentration for a period of n hours is calculated for n unit releases, i.e., the $\chi$ value for each hour is added to calculate the overall time integrated concentration. Note that this amounts to using a short-term equation repeatedly for a longer term release if $n>1$. This will lead to overestimates of $\chi_{10-t}$ with respect to what would be expected in reality. However use of these $\chi_{10-t}$'s is justified since they will only be used in comparison with $\chi$'s calculated in the same way, and only in a relative sense. Then, for example, for the 720-hour release duration, $\chi_{10-720}$ is calculated in the following manner.

For each 720 hr period starting every hour in the 5 year data period, a separate $\chi$ value is calculated. Let us call these $\chi_k$ , $k = 1,2,\ldots,m$, where $m$ = total no. of hourly observations = 5 yr x 365 d x 24 h - 720h ~ 43,000. When missing data in the data bases are considered this value drops down to ~ 42,000. A cumulative frequency graph is then constructed for these 42,000 $\chi_k$. Examples are shown in Figures E.1 - E.4 for release durations of 720 hrs, 72 hrs, 4 hrs, and 1 hr. Looking up the $\chi$ value corresponding to the 90% cumulative frequency yields us the $\chi$ value which is larger than 90% of all the $\chi_k$, or the $\chi$ value which will not be exceeded more than 10% of the time. Let us call this value $\chi_{10-t}$. For a release duration of 720 hrs, let us call this value $\chi_{10-720}$, for a 4 hr release $\chi_{10-4}$, etc. Note the stepwise nature of the cumulative frequency curve for a 1 hr release, reflecting the quantized nature of the atmospheric conditions used in the calculations. The $\chi_{10-t}$ values thus derived for various release durations are presented in Table E.6 for a ground level release based on 5 year data from St. John Airport. Note again that the release scenario used is a unit release every hour throughout each release duration.

### 1.4 "Percentage Criteria" for Different Release Durations and Derivation Hourly Stability-Wind Speed Scenarios

Once the $\chi_{10-t}$ values are calculated for each release duration t, there remains the task of deriving suitable scenarios from the tables such as those given in Tables E.2 - E.5, such that these scenarios would yield the $\chi_{10-t}$ value determined in the previous step. This is accomplished by using a "percentage criterion."

Let us return to Table E.2b as our example. Let us examine the 72 hr scenario, which was presented there for convenience. The smallest frequency of occurrence of a "61" condition within the 72 hrs after a "61" start condition is 2.1% at 60 hrs, i.e., there is at least a 2.1% chance that a "61" condition will occur at any given hour within the 72 hours following the given start condition. Hence, if we demand that our selected scenario for each hour is made up of the worst possible weather condition that might occur after a given start condition, our scenario will consist of 72 consecutive "61" conditions.

Putting it in another way, if we demand that the most conservative $\chi$ value for each hour never be exceeded (i.e., not be exceeded more than 0% of the time), our scenario will consist of 72 consecutive "61" conditions. It is clear that we can relax the "percentage criterion" of 0% up to 2.1%, and still end up with 72 consecutive "61" conditions.

If we increase our percentage criterion to, for example, 2.4%, i.e., we demand that the $\chi$ value for each hour not be exceeded more than 2.4 % of the time, we see that the scenario will consist of "61"s until the 36th hour, but that for the 36th hour, we should go to the next less conservative atmospheric condition, namely, "62." Hours 37-59 will again be "61," hour 60 will be "62," hours 61-72 will be "61." The situation is illustrated in Figure E.5 for a 72 hr ground-level release, with different "percentage criteria" varying from 0% to 30%. The 72 hr stability-wind speed scenario derived from the data set under consideration can thus be made less and less conservative, i.e., the overall 72 hr $\chi$ be made smaller, by selecting a larger "percentage criterion." Remembering that we are bound by the $\chi_{10}$ criterion which defines a "realistic conservative" scenario (Chapter A), i.e., that the overall (i.e., 72 hr cumulative) time integrated concentration should not be exceeded more than 10% of the time, we can adjust the "percentage criterion" such that the resulting 72 hr weather scenario will yield the corresponding $\chi_{10-72}$. This value had already been obtained using Figure E.2, and presented in Table E.6; it is 0.01106 $Ci{\cdot}s{\cdot}m^{-3}$. The value of "percentage criterion" $P_{10-72}$ that yields the weather scenario which in turn yields a $\chi_{10-72}$ of 0.01106 $Ci{\cdot}s{\cdot}m^{-3}$ is 25%. Clearly, a trial and error procedure is required which produces the types of curves shown in Figure E.5, in order to arrive at this value of 25% for the "percentage criterion."

The "percentage criteria" $P_{10-t}$ derived following the above procedure for various durations of release with a start condition of "61" using the data set under consideration are presented in Table E.7. For completeness, the corresponding $\chi_{10-t}$ value from Table E.6 are also included. Similar tables for elevated releases where receptor is at 1 km, 3 km, and 5 km are given in the Appendices.

The required stability-wind speed scenarios for each duration of release are essentially by-products of the procedure for determining the "percentage criteria." However, it is not practical to specify separate scenarios for each release duration. Justification will now be provided for using a single "percentage criterion" for all release durations, which will result in progressively more conservative scenarios for shorter releases.

## 1.5 Use of a Single "Percentage Criterion" for All Release Durations

If we use the lowest $P_{10-t}$ in Table E.7 for all the release durations, i.e. if we use 23% as the "percentage criterion" for the shorter durations, then, since this number is smaller than the other $P_{10-t}$ for the shorter durations, all the shorter duration scenarios will be more conservative than if we had used their corresponding $P_{10-t}$'s shown on the table. This means that, the shorter duration scenarios are progressively more conservative as the duration gets shorter - a very desirable feature. It also means that we only need to derive a single 720 hr scenario using its $P_{10-720}$, and then the earlier portions of this scenario can be used for shorter term releases. Based on this discussion, only 720 hr scenarios will be produced as the recommended scenarios in this report for all sites and release heights using the lowest percentage criterion $P_{10-t}$ in the tables corresponding to Table E.7 (Table E.7 is specifically for 5 years of St. John Airport data and for a ground-level release).

The implication of this result is that, for example, for a 72 hr scenario based on $P_{10-720}$, the corresponding $\chi$ over these 72 hours will be larger than $\chi_{10-72}$, and hence it will be exceeded less than 10% of the time. The scenarios will still be realistic for these shorter durations, since the percentage of times that the overall $\chi$'s for these scenarios will be exceeded still vary between 1-10%.

## 1.6 Usefulness of Using "Worst Case" "Start Conditions"

It was mentioned earlier in this section (first step in the pattern analysis) that since a release could start during any atmospheric condition, potentially there should be 30 weather scenarios, one for each possible start condition. It was also mentioned that it would be possible to show that use of only one worst case start condition could be justified based on comparisons of scenarios with various start conditions. We shall now proceed with these comparisons.

Figure E.6 shows the stability-wind speed scenarios derived using the above procedure for two start conditions, "61" and "34." The initial transient for the less conservative start condition "34" is clearly less conservative than the corresponding period for the "61" start. However, the scenarios are quite similar beyond this initial transient. It is more desirable from a practical point of view to specify only one weather scenario that can be used for estimating dose, rather than a separate scenario for each start condition (see Section 1.5). Hence, a scenario which yields the same $\chi_{10-t}$ over the period t as another one, but which is more conservative in the initial hours and thus which can also be used for shorter release durations, is preferable. Therefore, all the weather scenarios recommended in this report for various release levels and sites have a "worst case" start condition (i.e., the atmospheric condition with rank 1 in Table E.1).

## 1.7 Suitable Length of Data Record for Statistical Representativeness

It was mentioned in Chapter B.2 that, for pattern analysis purposes, a "suitable period" needs to be long enough so that year-to-year variability of weather would not introduce a bias into the derived weather scenarios. This implies that at least several years' data would be required. However, for practical purposes, it is desirable to analyze as short a period as possible, without jeopardizing the resulting scenarios.

In order to determine the length of data record that would be suitable for our purposes, the pattern analysis method developed in the previous sections was applied to five- and ten-year data sets from St. John Airport. The resulting scenarios for a 72 hr ground level release are shown in Figure E.7. The differences were deemed insignificant considering that even an hour-by-hour specification for any release duration beyond about 12 hours will not be practical and some averaging will be done which will 'overshadow' these differences. Hence, five-year data bases were used in all the pattern analyses in this project.

## 1.8 Hourly Stability-Wind Speed Scenarios - Summary

We shall now summarize the pattern analysis method developed in the previous sections for the stability-windspeed group and present the hourly scenarios derived for our example site, St. John Airport, for ground-level and elevated releases.

- The scenarios are based on a 5 year data set, corresponding to 1978-1983.
- The scenarios utilize a "worst case" start condition. This implies a "61" start condition for a ground level release, and for elevated releases, a "41" start condition for calculating dose estimates at a distance of 1 km from the source, a "51" start condition for 3 km, and a "61" again for 5 km.
- For elevated releases, the scenarios become similar to the ground-level release for distances beyond 5 km.
- A single scenario is derived for all release durations up to 720 hours based on a 720 hour release duration. It was derived using a "percentage criterion" such that it would produce a time integrated concentration $\chi_{10}$ which would not be exceeded more than 10% of the time when real 720 hour sequences of data are used. When the earlier portions of this scenario are used for shorter releases, it produces progressively more conservative scenarios. For example, if the first 24 hours of this scenario are used for a 24 hour release, the resulting time integrated concentration is expected not to be exceeded more than 2.5% of the time, rather than the less conservative number of 10% for a 720 hour release.

The hourly stability-windspeed scenarios derived for the ground-level and elevated releases (3 receptor locations for the elevated) using the method just outlined are presented in Figures E.8-E.11 for St. John Airport data.

These figures span several pages each. However, they are presented in full since they describe the repetitiveness of the diurnal pattern reached beyond the initial transient. This repetitiveness justifies the use of an average realistic and conservative scenario beyond the initial cycle. It is interesting to note that the diurnal variation is much stronger for the ground level release (Figure E.8, Table E.2b) than the 50 m release, $x = 1$ km (Figure E.9, Table E.3). This is due to the much stronger diurnal dependence of the stable classes (6j and 5j, where $j=1,2,...,5$, denotes the different wind speed classes, mostly occur at nighttime) which dominate the scenarios for the ground level release. The neutral class (4j) dominates the $H = 50$ m, $x = 1$ km scenario, and this class can be found to be more uniformly distributed throughout the day than the stable classes. A similar reasoning applies to the $H = 50$ m, $x = 3$ km and $x = 5$ km scenarios, which are dominated by the stable classes, but less than the ground level scenario. The importance of the stability classification scheme used in the study is thus evident. The procedure used for obtaining the average scenario from these figures will be described in Section 3., together with the procedure of combining the stability-windspeed scenario with the wind direction scenario. The pattern analysis method developed for deriving the wind direction scenario will now be described.

## 2. Pattern Analysis for Wind Direction

The pattern analysis method used for deriving the realistic and conservative wind direction scenario is also based on the basic approach used for the stability-windspeed that was described in Section 1 above.

There are 16 wind directions used in this study, as was described in Chapter B.2 (Table B.4). Using the terminology of the previous section, this implies that there are 16 "weather conditions" or "classes" in terms of wind direction. These are depicted in Figure E.12.

### 2.1 Wind Direction Classes and Their "Conservatism"

The first task in the analysis is to determine the "conservativeness" of each wind direction relative to other directions.

Since wind direction only enters the $\chi$ calculations through the lateral distance of a given receptor with respect to the plume centreline, "conservativeness" of a given direction relative to others is only meaningful when considered in the context of being persistent relative to that given receptor within a given duration of release. Hence, the most conservative wind direction will be the wind direction which occurs most frequently during the release period.

An absolute ranking of the direction classes similar to the ranking for stability-windspeed conditions given in Table E.1 is thus meaningless. Note that, for a specific site, it is entirely possible to have a certain wind direction to be highly correlated with a certain conservative stability-windspeed condition, which will make this wind direction more "conservative" than others. However, this combination may or may not occur that frequently. In the present pattern analysis method, stability-windspeed and wind direction were taken as two statistically independent groups as discussed in the beginning of Chapter B. To take into account in our final combined scenario the possibility of having certain conditions from the two groups correlated, the combining of the independently derived scenarios for the two groups is done in such a way that the resulting combined scenarios would be more conservative than if the groups were not assumed independent. This will be described in more detail in Section 3.

### 2.2 Frequency of Occurrence of Wind Direction Classes During a Given Release Period

It was explained above that for a given release duration the most "conservative" direction would be the most frequently occurring direction during that period. For our purposes, it is immaterial to know which specific direction this is; all we need to find out is the frequency of occurrence of this most frequently occurring direction.

Taking a 720 hr release duration as an example, there are close to 42,000 of these scenarios in a given 5 year data record. The number of hourly occurrences of each wind direction during each 720-hour period is then computed for each selected site. An example frequency distribution is shown in Figure E.13a for St. John Airport data.

The cumulative frequency distributions of these number of hourly occurrences of each direction are then plotted. The cumulative frequency distribution corresponding to the example of Figure E.13a is in Figure E.13b. In this figure, 90% on the ordinate indicates that 90% of the ~ 42,000 scenarios contain less than 183 hourly occurrences of direction "10," and 10% contain more than 183 hourly occurrences of direction "10."

In Chapter A, a "realistic conservative" scenario was defined as a scenario which would yield a time integrated concentration that will not be exceeded more than 10% of the time.

In accordance with the intent of this 10% criterion, the number of hourly occurrences of each direction corresponding to the 90% cumulative frequency level is selected for each direction from the above described cumulative frequency distributions. For a release of 720 hours duration, these "number of hourly occurrences of each direction which is not exceeded in more than 10% of the ~42,000 scenarios" are presented in Table E.8. It is seen that the maximum of these occurrences is 183 occurrences at direction class "10." We are not really interested in the specific direction class. We take the "183 occurrences" as the frequency of occurrence of the most frequently occurring direction for a 720 hour release, keeping in mind that this number already reflects the 10% criterion in our definition of a realistic conservative weather scenario. Putting it in other words, the wind will be taken to be blowing toward the critical boundary for 183 hours during a 720 hour release.

These maximum numbers of hourly occurrences corresponding to each duration of release considered in this study are presented in Table E.9 and plotted in Figure E.14. From the figure it is interesting to see that no matter what durations of release were used the curve will always be the same.

In Figure E.14, taking a 12-hour release as an example, out of the ~ 42,000 12-hour periods available in the 5-year data base, only 10% or ~ 4200 12-hour periods will contain more than 6.1 hours (51% of 12) of wind blowing in the same direction.

Using the solid curve in this figure as the wind direction scenario requires hourly specification of the frequency of wind in a given direction. This is not very desirable from a practical point of view. In order to have a direction scenario which is more practical to use, as well as being more conservative, a step function shown by the dotted line in Figure E.14 is used as the wind direction scenario.

Hence, for example for a release duration between 1 and 12 hours, the percentage frequency that belongs to the shorter duration, i.e., that for a 1-hour release is utilized. This results in consistently more conservative direction scenarios for the durations between the end points of the selected intervals. The intervals (i.e., 1-12, 12-48, 48-96, 96-720 hours) are selected rather arbitrarily for the practical purpose of prescribing a minimum number of wind direction frequencies to be used in the final weather scenarios.

The summary wind direction scenario for St. John Airport is as follows: for a release of less than or equal to 12 hours, the wind is taken to be always blowing toward the nearest point on the boundary, when release duration is greater than 12 hours and shorter than or equal to 48 hours, the wind is taken to blow towards nearest point on the boundary, only 51% of the time, etc.

## 3. Combining of Stability-Windspeed and Wind Direction Scenarios

The stability-wind speed scenarios and the wind direction scenarios described earlier are combined to give summary weather scenarios for each of the three sites, St. John, Quebec and Trenton. In order to simplify the scenarios, the atmospheric condition(s) which produce the same concentration as the average of the time integrated concentrations over an interval of interest is (are) used to represent the atmospheric conditions over that interval.

The mixing layer heights corresponding to atmospheric stabilities for the winter months are used to represent the mixing layer heights in the weather scenario as these are the most conservative values. If an average concentration which does not correspond closely to an actual value from Table E.1 is calculated, this concentration is expressed as a combination of the concentrations of the two most frequently occurring atmospheric conditions in the time interval.

The length of each interval is determined by considering the following two factors:

(1) wind direction scenario, and
(2) the release scenario, which is defined roughly by CSA N288.2 as:
    (a) short-term release-less than one hour
    (b) prolonged term release-less than a day
    (c) long-term release-longer than one day

For elevated releases, since the ordering of atmospheric conditions does not change for downwind distances greater than 5 km, it is suggested that the recommended scenario for the 5 km downwind distance be used for downwind distances greater than 5 km.

The summary weather scenarios for all three sites for ground-level releases and elevated releases for 1 km, 3 km and 5 km may be found in Chapter F. The graphs of the detailed 720 hour scenarios which were used to determine these summary scenarios are given in Appendices A2, A3 and A4, for the airports at St. John, Quebec and Trenton, respectively. The final recommended scenarios that could be used for any site are then given in Chapter G. These are derived from the three site-specific sets of scenarios by extracting the most conservative combination of conditions for a given interval.

TABLE E.1: Relative Ranking of the Atmospheric Conditions for Ground Level and Elevated Unit Releases (A rank of 1 indicates most conservative condition)

| Atm | H=0 m, x =1 km | | H=50 m , x=1 km | | H=50 m , x=3 km | | H=50 m , x=5 km | |
|---|---|---|---|---|---|---|---|---|
| Cond | $\chi(\mathrm{Ci \cdot s \cdot m^{-3}})$ | rank | $\chi(\mathrm{Ci \cdot s \cdot m^{-3}})$ | rank | $\chi(\mathrm{Ci \cdot s \cdot m^{-3}})$ | rank | $\chi(\mathrm{Ci \cdot s \cdot m^{-3}})$ | rank |
| 61 | $5.64 \times 10^{-4}$ | 1 | $3.24 \times 10^{-7}$ | 26 | $2.56 \times 10^{-5}$ | 2 | $2.86 \times 10^{-5}$ | 1 |
| 62 | $2.82 \times 10^{-4}$ | 2 | $1.62 \times 10^{-7}$ | 27 | $1.28 \times 10^{-5}$ | 5 | $1.43 \times 10^{-5}$ | 3 |
| 63 | $1.41 \times 10^{-4}$ | 4 | $8.10 \times 10^{-8}$ | 28 | $6.40 \times 10^{-6}$ | 9 | $7.15 \times 10^{-6}$ | 6 |
| 64* | $7.06 \times 10^{-5}$ | 7 | $4.05 \times 10^{-8}$ | 29 | $3.20 \times 10^{-6}$ | 14 | $3.58 \times 10^{-6}$ | 10 |
| 65* | $3.53 \times 10^{-5}$ | 11 | $2.03 \times 10^{-8}$ | 30 | $1.60 \times 10^{-6}$ | 20 | $1.79 \times 10^{-6}$ | 15 |
| 51* | $2.66 \times 10^{-4}$ | 3 | $3.78 \times 10^{-5}$ | 3 | $3.52 \times 10^{-5}$ | 1 | $2.28 \times 10^{-5}$ | 2 |
| 52 | $1.33 \times 10^{-4}$ | 5 | $1.89 \times 10^{-5}$ | 7 | $1.76 \times 10^{-5}$ | 4 | $1.14 \times 10^{-5}$ | 4 |
| 53 | $6.66 \times 10^{-5}$ | 8 | $9.45 \times 10^{-6}$ | 12 | $8.80 \times 10^{-6}$ | 8 | $5.70 \times 10^{-6}$ | 7 |
| 54 | $3.33 \times 10^{-5}$ | 12 | $4.73 \times 10^{-6}$ | 17 | $4.40 \times 10^{-6}$ | 13 | $2.85 \times 10^{-6}$ | 11 |
| 55* | $1.66 \times 10^{-5}$ | 16 | $2.36 \times 10^{-6}$ | 22 | $2.20 \times 10^{-6}$ | 18 | $1.43 \times 10^{-6}$ | 16 |
| 41 | $1.27 \times 10^{-4}$ | 6 | $6.61 \times 10^{-5}$ | 1 | $2.0 \times 10^{-5}$ | 3 | $9.78 \times 10^{-6}$ | 5 |
| 42 | $6.35 \times 10^{-5}$ | 10 | $3.31 \times 10^{-5}$ | 4 | $1.0 \times 10^{-5}$ | 7 | $4.89 \times 10^{-6}$ | 8 |
| 43 | $3.18 \times 10^{-5}$ | 15 | $1.66 \times 10^{-5}$ | 8 | $5.0 \times 10^{-6}$ | 11 | $2.45 \times 10^{-6}$ | 12 |
| 44 | $1.59 \times 10^{-5}$ | 19 | $8.28 \times 10^{-6}$ | 13 | $2.5 \times 10^{-6}$ | 16 | $1.22 \times 10^{-6}$ | 17 |
| 45 | $7.94 \times 10^{-6}$ | 23 | $4.14 \times 10^{-6}$ | 18 | $1.25 \times 10^{-6}$ | 22 | $6.11 \times 10^{-7}$ | 21 |
| 31 | $6.4 \times 10^{-5}$ | 9 | $5.06 \times 10^{-5}$ | 2 | $1.04 \times 10^{-5}$ | 6 | $4.78 \times 10^{-6}$ | 9 |
| 32 | $3.2 \times 10^{-5}$ | 14 | $2.53 \times 10^{-5}$ | 6 | $5.22 \times 10^{-6}$ | 10 | $2.39 \times 10^{-6}$ | 13 |
| 33 | $1.6 \times 10^{-5}$ | 18 | $1.27 \times 10^{-5}$ | 11 | $2.61 \times 10^{-6}$ | 15 | $1.20 \times 10^{-6}$ | 18 |
| 34 | $8 \times 10^{-6}$ | 22 | $6.33 \times 10^{-6}$ | 16 | $1.31 \times 10^{-6}$ | 21 | $5.98 \times 10^{-7}$ | 22 |
| 35 | $4 \times 10^{-6}$ | 26 | $3.16 \times 10^{-6}$ | 21 | $6.53 \times 10^{-7}$ | 25 | $2.99 \times 10^{-7}$ | 25 |
| 21 | $3.28 \times 10^{-5}$ | 13 | $2.94 \times 10^{-5}$ | 5 | $4.96 \times 10^{-6}$ | 12 | $2.2 \times 10^{-6}$ | 14 |
| 22 | $1.64 \times 10^{-5}$ | 17 | $1.47 \times 10^{-5}$ | 9 | $2.48 \times 10^{-6}$ | 17 | $1.1 \times 10^{-6}$ | 19 |
| 23 | $8.2 \times 10^{-6}$ | 21 | $7.35 \times 10^{-6}$ | 14 | $1.24 \times 10^{-6}$ | 23 | $5.50 \times 10^{-7}$ | 23 |
| 24* | $4.1 \times 10^{-6}$ | 25 | $3.68 \times 10^{-6}$ | 19 | $6.20 \times 10^{-7}$ | 26 | $2.75 \times 10^{-7}$ | 26 |
| 25* | $2.05 \times 10^{-6}$ | 28 | $1.84 \times 10^{-6}$ | 23 | $3.10 \times 10^{-7}$ | 28 | $1.38 \times 10^{-7}$ | 28 |
| 11 | $1.4 \times 10^{-5}$ | 20 | $1.36 \times 10^{-5}$ | 10 | $1.92 \times 10^{-6}$ | 19 | $8.4 \times 10^{-7}$ | 20 |
| 12 | $7.01 \times 10^{-6}$ | 24 | $6.8 \times 10^{-6}$ | 15 | $9.6 \times 10^{-7}$ | 24 | $4.2 \times 10^{-7}$ | 24 |
| 13 | $3.505 \times 10^{-6}$ | 27 | $3.4 \times 10^{-6}$ | 20 | $4.8 \times 10^{-7}$ | 27 | $2.1 \times 10^{-7}$ | 27 |
| 14* | $1.75 \times 10^{-6}$ | 29 | $1.7 \times 10^{-6}$ | 24 | $2.4 \times 10^{-7}$ | 29 | $1.05 \times 10^{-7}$ | 29 |
| 15* | $8.8 \times 10^{-7}$ | 30 | $8.5 \times 10^{-7}$ | 25 | $1.2 \times 10^{-7}$ | 30 | $5.25 \times 10^{-8}$ | 30 |

*: These classes cannot occur under the STAR scheme.

TABLE E.2a: Hourly frequency of occurrence of different atmospheric conditions ij for a start condition of 61 (72 hour period, 5 years of data for St. John Airport, ground level release).

| [illegible] | 61 | 62 | 51 | 63 | 52 | 41 | 64 | 53 | 31 | 42 | 65 | 54 | 21 | 32 | 43 | 55 | 22 | 33 | 44 | 11 | 23 | 34 | 45 | 12 | 24 | 35 | 13 | 25 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2440. | 404. | . | 89. | 71. | 93. | . | 83. | 193. | 53. | . | 29. | 56. | 28. | 36. | . | 11. | 7. | 32. | . | . | 2. | . | . | . | . | . | . | . | . |
| 2 | 2025. | 372. | . | 98. | 86. | 137. | . | 89. | 207. | 108. | . | 33. | 110. | 57. | 74. | . | 21. | 29. | 92. | 11. | 5. | 17. | 1. | . | . | . | . | . | . | . |
| 3 | 1703. | 348. | . | 87. | 80. | 193. | . | 76. | 216. | 195. | . | 43. | 136. | 79. | 121. | . | 67. | 67. | 142. | 28. | 19. | 50. | 5. | . | . | . | . | . | . | . |
| 4 | 1400. | 298. | . | 80. | 59. | 144. | . | 83. | 215. | 158. | . | 52. | 153. | 87. | 172. | . | 96. | 111. | 253. | 44. | 57. | 96. | 11. | . | . | . | . | . | . | . |
| 5 | 1198. | 259. | . | 72. | 58. | 146. | . | 71. | 213. | 160. | . | 39. | 155. | 88. | 212. | . | 122. | 126. | 288. | 39. | 119. | 163. | 22. | . | . | . | . | . | . | . |
| 6 | 902. | 207. | . | 55. | 40. | 126. | . | 74. | 205. | 186. | . | 51. | 195. | 98. | 238. | . | 141. | 128. | 486. | 72. | 139. | 224. | 48. | . | . | . | . | . | . | . |
| 7 | 689. | 177. | . | 46. | 30. | 123. | . | 64. | 180. | 186. | . | 43. | 195. | 98. | 231. | . | 149. | 192. | 636. | 68. | 195. | 294. | 73. | . | . | . | . | . | . | . |
| 8 | 510. | 146. | . | 38. | 31. | 103. | . | 55. | 104. | 191. | . | 44. | 137. | 102. | 239. | . | 148. | 151. | 774. | 63. | 219. | 329. | 118. | . | . | . | . | . | . | . |
| 9 | 301. | 108. | . | 38. | 25. | 81. | . | 56. | 164. | 175. | . | 32. | 128. | 106. | 258. | . | 157. | 196. | 931. | 62. | 213. | 368. | 148. | . | . | . | . | . | . | . |
| 10 | 273. | 95. | . | 40. | 26. | 65. | . | 44. | 134. | 160. | . | 27. | 117. | 102. | 297. | . | 142. | 155. | 1041. | 56. | 210. | 403. | 198. | . | . | . | . | . | . | . |
| 11 | 189. | 84. | . | 41. | 29. | 53. | . | 46. | 102. | 152. | . | 24. | 113. | 93. | 305. | . | 191. | 165. | 1197. | 51. | 193. | 394. | 208. | . | . | . | . | . | . | . |
| 12 | 153. | 86. | . | 51. | 42. | 45. | . | 54. | 66. | 144. | . | 34. | 95. | 83. | 316. | . | 130. | 154. | 1283. | 46. | 196. | 372. | 227. | . | . | . | . | . | . | . |
| 13 | 153. | 98. | . | 53. | 41. | 39. | . | 69. | 46. | 143. | . | 38. | 70. | 63. | 313. | . | 118. | 119. | 1307. | 48. | 177. | 301. | 241. | . | . | . | . | . | . | . |
| 14 | 176. | 109. | . | 70. | 38. | 43. | . | 103. | 35. | 134. | . | 35. | 47. | 44. | 299. | . | 87. | 99. | 1445. | 47. | 175. | 312. | 239. | . | . | . | . | . | . | . |
| 15 | 233. | 126. | . | 74. | 77. | 51. | . | 130. | 27. | 128. | . | 66. | 25. | 31. | 301. | . | 82. | 95. | 1439. | 38. | 128. | 265. | 250. | . | . | . | . | . | . | . |
| 16 | 305. | 156. | . | 98. | 86. | 59. | . | 152. | 24. | 131. | . | 80. | 11. | 30. | 303. | . | 55. | 75. | 1413. | 25. | 112. | 205. | 252. | . | . | . | . | . | . | . |
| 17 | 377. | 197. | . | 112. | 102. | 63. | . | 165. | 19. | 133. | . | 95. | 6. | 25. | 319. | . | 40. | 70. | 1368. | 13. | 83. | 164. | 226. | . | . | . | . | . | . | . |
| 18 | 461. | 233. | . | 118. | 111. | 64. | . | 177. | 13. | 149. | . | 104. | 4. | 16. | 330. | . | 29. | 55. | 1330. | 9. | 91. | 116. | 222. | . | . | . | . | . | . | . |
| 19 | 536. | 251. | . | 142. | 119. | 73. | . | 191. | 7. | 137. | . | 123. | 2. | 17. | 334. | . | 19. | 40. | 1279. | 1. | 26. | 73. | 212. | . | . | . | . | . | . | . |
| 20 | 615. | 294. | . | 142. | 127. | 79. | . | 183. | 5. | 150. | . | 140. | 1. | 13. | 319. | . | 8. | 33. | 1221. | . | 11. | 38. | 206. | . | . | . | . | . | . | . |
| 21 | 696. | 307. | . | 147. | 125. | 92. | . | 202. | 4. | 152. | . | 145. | 1. | 6. | 311. | . | 5. | 11. | 1161. | . | 3. | 12. | 197. | . | . | . | . | . | . | . |
| 22 | 790. | 310. | . | 173. | 121. | 107. | . | 200. | 1. | 145. | . | 146. | 1. | 4. | 306. | . | 5. | 2. | 1075. | . | . | 9. | 187. | . | . | . | . | . | . | . |
| 23 | 839. | 321. | . | 152. | 130. | 117. | . | 192. | . | 197. | . | 190. | . | 2. | 300. | . | 1. | . | 1042. | . | . | 1. | 188. | . | . | . | . | . | . | . |
| 24 | 887. | 301. | . | 135. | 135. | 135. | . | 165. | . | 160. | . | 146. | . | . | 310. | . | . | 1. | 1016. | . | . | 1. | 185. | . | . | . | . | . | . | . |
| 25 | 812. | 279. | . | 120. | 103. | 144. | . | 146. | 53. | 191. | . | 123. | 17. | 13. | 336. | . | 4. | 12. | 1023. | . | . | 8. | 193. | . | . | . | . | . | . | . |
| 26 | 740. | 252. | . | 102. | 83. | 138. | . | 124. | 78. | 212. | . | 111. | 37. | 29. | 342. | . | 11. | 21. | 1067. | 3. | 1. | 22. | 204. | . | . | . | . | . | . | . |
| 27 | 658. | 215. | . | 89. | 71. | 137. | . | 108. | 87. | 216. | . | 92. | 48. | 37. | 374. | . | 20. | 47. | 1089. | 11. | 11. | 45. | 222. | . | . | . | . | . | . | . |
| 28 | 574. | 178. | . | 79. | 67. | 130. | . | 87. | 86. | 219. | . | 90. | 61. | 48. | 380. | . | 37. | 67. | 1134. | 18. | 29. | 69. | 229. | . | . | . | . | . | . | . |
| 29 | 479. | 137. | . | 72. | 57. | 129. | . | 76. | 99. | 226. | . | 80. | 60. | 50. | 370. | . | 52. | 76. | 1172. | 26. | 64. | 101. | 248. | . | . | . | . | . | . | . |
| 30 | 379. | 121. | . | 58. | 47. | 129. | . | 72. | 96. | 219. | . | 73. | 55. | 51. | 366. | . | 76. | 80. | 1208. | 33. | 90. | 193. | 279. | . | . | . | . | . | . | . |
| 31 | 301. | 99. | . | 40. | 39. | 116. | . | 60. | 90. | 196. | . | 64. | 59. | 58. | 380. | . | 78. | 91. | 1247. | 36. | 123. | 190. | 302. | . | . | . | . | . | . | . |
| 32 | 232. | 81. | . | 41. | 31. | 92. | . | 69. | 82. | 194. | . | 57. | 53. | 58. | 369. | . | 91. | 98. | 1295. | 37. | 125. | 242. | 335. | . | . | . | . | . | . | . |
| 33 | 161. | 65. | . | 42. | 30. | 89. | . | 53. | 79. | 201. | . | 44. | 54. | 60. | 342. | . | 89. | 96. | 1382. | 39. | 140. | 250. | 350. | . | . | . | . | . | . | . |
| 34 | 118. | 55. | . | 35. | 32. | 74. | . | 49. | 77. | 189. | . | 41. | 40. | 60. | 329. | . | 89. | 119. | 1459. | 40. | 132. | 263. | 381. | . | . | . | . | . | . | . |
| 35 | 95. | 49. | . | 38. | 30. | 62. | . | 55. | 59. | 174. | . | 42. | 45. | 62. | 334. | . | 91. | 124. | 1505. | 32. | 135. | 250. | 405. | . | . | . | . | . | . | . |
| 36 | 81. | 50. | . | 46. | 38. | 65. | . | 52. | 44. | 157. | . | 47. | 48. | 59. | 338. | . | 79. | 121. | 1536. | 32. | 125. | 245. | 394. | . | . | . | . | . | . | . |
| 37 | 91. | 75. | . | 52. | 34. | 58. | . | 67. | 32. | 146. | . | 45. | 38. | 47. | 345. | . | 78. | 100. | 1553. | 31. | 121. | 247. | 405. | . | . | . | . | . | . | . |
| 38 | 114. | 99. | . | 70. | 40. | 54. | . | 89. | 21. | 148. | . | 62. | 23. | 29. | 352. | . | 59. | 81. | 1547. | 30. | 113. | 252. | 394. | . | . | . | . | . | . | . |
| 39 | 158. | 118. | . | 78. | 49. | 59. | . | 113. | 16. | 149. | . | 65. | 12. | 23. | 356. | . | 61. | 62. | 1529. | 23. | 97. | 229. | 380. | . | . | . | . | . | . | . |
| 40 | 193. | 142. | . | 108. | 64. | 66. | . | 131. | 9. | 147. | . | 80. | 11. | 24. | 366. | . | 42. | 44. | 1513. | 17. | 73. | 188. | 359. | . | . | . | . | . | . | . |
| 41 | 237. | 175. | . | 117. | 83. | 78. | . | 136. | 13. | 143. | . | 99. | 7. | 19. | 353. | . | 39. | 35. | 1525. | 15. | 56. | 122. | 325. | . | . | . | . | . | . | . |
| 42 | 287. | 198. | . | 130. | 93. | 90. | . | 159. | 8. | 142. | . | 119. | 5. | 16. | 343. | . | 20. | 28. | 1478. | 7. | 34. | 104. | 301. | . | . | . | . | . | . | . |
| 43 | 346. | 240. | . | 141. | 92. | 103. | . | 169. | 5. | 155. | . | 131. | 3. | 12. | 347. | . | 13. | 28. | 1417. | 3. | 20. | 42. | 290. | . | . | . | . | . | . | . |
| 44 | 414. | 271. | . | 199. | 98. | 119. | . | 177. | 2. | 163. | . | 139. | 2. | 7. | 353. | . | 3. | 21. | 1354. | 3. | 9. | 33. | 265. | . | . | . | . | . | . | . |
| 45 | 479. | 288. | . | 150. | 106. | 134. | . | 193. | 2. | 179. | . | 155. | 2. | 1. | 393. | . | 2. | 13. | 1271. | 1. | 3. | 19. | 246. | . | . | . | . | . | . | . |
| 46 | 544. | 309. | . | 156. | 107. | 149. | . | 197. | 1. | 170. | . | 165. | 1. | 3. | 329. | . | 1. | 3. | 1213. | . | 1. | 3. | 230. | . | . | . | . | . | . | . |
| 47 | 634. | 322. | . | 155. | 112. | 161. | . | 219. | . | 171. | . | 157. | . | 1. | 319. | . | . | 1. | 1142. | . | . | . | 218. | . | . | . | . | . | . | . |
| 48 | 646. | 321. | . | 148. | 115. | 172. | . | 198. | . | 180. | . | 161. | 2. | 1. | 308. | . | . | 1. | 1116. | . | . | . | 200. | . | . | . | . | . | . | . |
| 49 | 617. | 289. | . | 149. | 94. | 177. | . | 160. | 46. | 207. | . | 152. | 11. | 29. | 334. | . | 1. | 19. | 1091. | . | . | 2. | 209. | . | . | . | . | . | . | . |
| 50 | 559. | 270. | . | 129. | 81. | 175. | . | 191. | 62. | 211. | . | 144. | 33. | 38. | 352. | . | 5. | 31. | 1119. | 2. | 7. | 16. | 202. | . | . | . | . | . | . | . |
| 51 | 500. | 230. | . | 118. | 68. | 182. | . | 115. | 70. | 227. | . | 136. | 38. | 53. | 348. | . | 19. | 56. | 1150. | 6. | 15. | 36. | 215. | . | . | . | . | . | . | . |
| 52 | 453. | 183. | . | 117. | 61. | 177. | . | 92. | 75. | 216. | . | 119. | 45. | 61. | 351. | . | 34. | 72. | 1192. | 10. | 25. | 71. | 223. | . | . | . | . | . | . | . |
| 53 | 402. | 157. | . | 101. | 44. | 166. | . | 74. | 76. | 226. | . | 116. | 44. | 63. | 349. | . | 43. | 79. | 1192. | 18. | 59. | 105. | 263. | . | . | . | . | . | . | . |
| 54 | 333. | 141. | . | 91. | 32. | 153. | . | 62. | 85. | 232. | . | 102. | 47. | 68. | 331. | . | 60. | 73. | 1234. | 23. | 76. | 154. | 280. | . | . | . | . | . | . | . |
| 55 | 285. | 113. | . | 77. | 27. | 135. | . | 47. | 83. | 219. | . | 76. | 48. | 70. | 337. | . | 61. | 82. | 1258. | 24. | 109. | 193. | 313. | . | . | . | . | . | . | . |
| 56 | 220. | 98. | . | 59. | 26. | 122. | . | 44. | 82. | 213. | . | 69. | 52. | 76. | 334. | . | 81. | 94. | 1318. | 24. | 106. | 223. | 326. | . | . | . | . | . | . | . |
| 57 | 170. | 79. | . | 49. | 19. | 108. | . | 41. | 76. | 201. | . | 50. | 46. | 77. | 331. | . | 85. | 99. | 1396. | 29. | 125. | 237. | 362. | . | . | . | . | . | . | . |
| 58 | 125. | 62. | . | 33. | 29. | 92. | . | 30. | 63. | 187. | . | 48. | 44. | 72. | 348. | . | 88. | 116. | 1445. | 33. | 123. | 247. | 388. | . | . | . | . | . | . | . |
| 59 | 90. | 60. | . | 46. | 26. | 80. | . | 39. | 58. | 162. | . | 48. | 50. | 67. | 364. | . | 85. | 109. | 1492. | 28. | 113. | 266. | 394. | . | . | . | . | . | . | . |
| 60 | 76. | 69. | . | 56. | 29. | 87. | . | 46. | 91. | 164. | . | 48. | 43. | 62. | 363. | . | 91. | 102. | 1496. | 27. | 112. | 258. | 419. | . | . | . | . | . | . | . |
| 61 | 90. | 71. | . | 48. | 27. | 73. | . | 52. | 26. | 154. | . | 60. | 34. | 99. | 367. | . | 75. | 87. | 1521. | 26. | 112. | 292. | 421. | . | . | . | . | . | . | . |
| 62 | 122. | 94. | . | 83. | 40. | 67. | . | 78. | 22. | 146. | . | 78. | 22. | 46. | 376. | . | 60. | 75. | 1510. | 17. | 102. | 215. | 416. | . | . | . | . | . | . | . |
| 63 | 171. | 108. | . | 97. | 61. | 55. | . | 98. | 16. | 162. | . | 92. | 14. | 29. | 373. | . | 45. | 57. | 1482. | 19. | 85. | 172. | 404. | . | . | . | . | . | . | . |
| 64 | 212. | 147. | . | 116. | 69. | 58. | . | 109. | 13. | 138. | . | 111. | 5. | 25. | 364. | . | 32. | 52. | 1456. | 9. | 81. | 157. | 383. | . | . | . | . | . | . | . |
| 65 | 283. | 167. | . | 131. | 82. | 62. | . | 123. | 13. | 137. | . | 137. | 4. | 21. | 339. | . | 47. | 44. | 1393. | 8. | 49. | 132. | 368. | . | . | . | . | . | . | . |
| 66 | 348. | 187. | . | 147. | 89. | 73. | . | 139. | 11. | 161. | . | 154. | 2. | 17. | 378. | . | 38. | 39. | 1343. | 6. | 30. | 90. | 333. | . | . | . | . | . | . | . |
| 67 | 408. | 213. | . | 170. | 97. | 87. | . | 149. | 6. | 172. | . | 171. | 2. | 13. | 399. | . | 23. | 31. | 1272. | 10. | 25. | 57. | 322. | . | . | . | . | . | . | . |
| 68 | 477. | 253. | . | 182. | 91. | 100. | . | 158. | 5. | 174. | . | 170. | 3. | 7. | 348. | . | 14. | 25. | 1221. | 3. | 13. | 34. | 305. | . | . | . | . | . | . | . |
| 69 | 543. | 285. | . | 200. | 99. | 117. | . | 178. | 3. | 170. | . | 165. | 3. | 9. | 339. | . | 18. | 19. | 1191. | 1. | 6. | 11. | 283. | . | . | . | . | . | . | . |
| 70 | 619. | 298. | . | 200. | 96. | 139. | . | 178. | 1. | 174. | . | 170. | 3. | 5. | 319. | . | 9. | 6. | 1110. | . | 1. | 9. | 252. | . | . | . | . | . | . | . |
| 71 | 671. | 315. | . | 202. | 95. | 159. | . | 153. | 3. | 173. | . | 178. | . | . | 310. | . | 3. | 9. | 1058. | . | . | 1. | 252. | . | . | . | . | . | . | . |
| 72 | 723. | 295. | . | 188. | 89. | 174. | . | 146. | 2. | 187. | . | 182. | 2. | . | 307. | . | 1. | 2. | 1038. | . | . | 2. | 239. | . | . | . | . | . | . | . |

**TABLE E.2b:** Percentage frequency of occurrence of different atmospheric conditions ij for a start condition of 61 (72 hour period, 5 years of data for St. John Airport, ground level release).

| [illegible] | 61 | 62 | 51 | 63 | 52 | 41 | 64 | 53 | 31 | 42 | 65 | 54 | 21 | 32 | 43 | 55 | 22 | 33 | 44 | 11 | 23 | 34 | 45 | 12 | 24 | 35 | 13 | 25 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 68.2 | 11.3 | .0 | 2.5 | 2.0 | 2.6 | .0 | 2.3 | 4.0 | 1.5 | .0 | .8 | 1.6 | .8 | 1.0 | .0 | .3 | .2 | .9 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 2 | 56.6 | 10.4 | .0 | 2.7 | 2.4 | 3.8 | .0 | 2.5 | 5.8 | 3.0 | .0 | .9 | 3.1 | 1.6 | 2.1 | .0 | .9 | .7 | 2.6 | .3 | .1 | .5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 3 | 47.6 | 9.7 | .0 | 2.4 | 2.2 | 4.1 | .0 | 2.1 | 6.0 | 4.1 | .0 | 1.2 | 3.8 | 2.2 | 3.4 | .0 | 1.9 | 1.9 | 4.5 | .8 | .5 | 1.4 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 4 | 39.1 | 8.3 | .0 | 2.5 | 1.6 | 4.0 | .0 | 2.3 | 6.0 | 4.4 | .0 | 1.5 | 4.3 | 2.4 | 4.8 | .0 | 2.7 | 3.1 | 7.1 | 1.2 | 1.6 | 2.7 | .3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 5 | 32.1 | 7.2 | .0 | 2.0 | 1.4 | 4.1 | .0 | 2.0 | 6.0 | 4.5 | .0 | 1.1 | 4.3 | 2.5 | 5.9 | .0 | 3.4 | 3.5 | 10.0 | 1.6 | 3.2 | 4.6 | .6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 6 | 25.2 | 5.8 | .0 | 1.5 | 1.1 | 3.5 | .0 | 2.1 | 5.7 | 5.2 | .0 | 1.4 | 4.1 | 2.7 | 6.4 | .0 | 3.9 | 3.6 | 13.6 | 2.0 | 4.4 | 6.3 | 1.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 7 | 19.3 | 4.9 | .0 | 1.3 | .8 | 3.4 | .0 | 1.8 | 5.3 | 5.2 | .0 | 1.2 | 4.1 | 2.7 | 6.5 | .0 | 4.2 | 4.0 | 17.8 | 1.9 | 5.5 | 8.2 | 2.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 8 | 14.3 | 4.1 | .0 | 1.1 | .9 | 2.9 | .0 | 1.5 | 5.1 | 5.3 | .0 | 1.2 | 3.8 | 2.9 | 6.7 | .0 | 4.1 | 4.2 | 21.6 | 1.8 | 6.1 | 9.1 | 3.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 9 | 10.7 | 3.0 | .0 | 1.1 | .7 | 2.3 | .0 | 1.6 | 4.6 | 4.9 | .0 | .9 | 3.6 | 3.0 | 7.2 | .0 | 4.4 | 4.1 | 26.0 | 1.7 | 6.0 | 10.3 | 4.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 10 | 7.6 | 2.7 | .0 | 1.1 | .7 | 1.8 | .0 | 1.2 | 3.7 | 4.5 | .0 | .8 | 3.3 | 2.9 | 8.3 | .0 | 4.0 | 4.3 | 29.1 | 1.6 | 5.9 | 11.3 | 5.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 11 | 5.3 | 2.3 | .0 | 1.1 | .8 | 1.5 | .0 | 1.3 | 2.9 | 4.2 | .0 | .7 | 3.2 | 2.6 | 8.5 | .0 | 3.9 | 4.6 | 33.5 | 1.4 | 5.4 | 11.0 | 5.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 12 | 4.3 | 2.4 | .0 | 1.4 | 1.2 | 1.3 | .0 | 1.5 | 1.8 | 4.0 | .0 | 1.0 | 2.7 | 2.3 | 8.8 | .0 | 3.6 | 4.3 | 35.9 | 1.3 | 5.5 | 10.4 | 6.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 13 | 4.3 | 2.7 | .0 | 1.5 | 1.1 | 1.1 | .0 | 1.9 | 1.3 | 4.0 | .0 | 1.1 | 2.0 | 1.8 | 8.8 | .0 | 3.3 | 3.3 | 38.8 | 1.3 | 5.5 | 9.5 | 6.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 14 | 4.9 | 3.0 | .0 | 2.0 | 1.6 | 1.2 | .0 | 2.9 | 1.0 | 3.7 | .0 | 1.5 | 1.3 | 1.2 | 8.4 | .0 | 2.4 | 2.0 | 40.4 | 1.3 | 4.9 | 8.7 | 6.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 15 | 6.5 | 3.8 | .0 | 2.1 | 2.2 | 1.4 | .0 | 3.6 | .8 | 3.6 | .0 | 1.8 | .7 | .9 | 8.4 | .0 | 2.3 | 2.7 | 40.2 | 1.1 | 3.6 | 7.4 | 7.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 16 | 8.5 | 4.4 | .0 | 2.7 | 2.4 | 1.6 | .0 | 4.2 | .7 | 3.7 | .0 | 2.3 | .3 | .8 | 8.5 | .0 | 1.5 | 2.1 | 39.6 | .7 | 3.1 | 5.7 | 7.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 17 | 10.5 | 5.5 | .0 | 3.1 | 2.9 | 1.8 | .0 | 4.6 | .3 | 3.7 | .0 | 2.7 | .2 | .7 | 8.9 | .0 | 1.1 | 2.0 | 38.2 | .4 | 2.3 | 4.6 | 6.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 18 | 12.9 | 6.5 | .0 | 3.3 | 3.1 | 1.8 | .0 | 4.9 | .4 | 4.2 | .0 | 2.9 | .1 | .4 | 9.2 | .0 | .8 | 1.5 | 37.2 | .1 | 1.1 | 3.2 | 6.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 19 | 15.0 | 7.0 | .0 | 4.0 | 3.3 | 2.0 | .0 | 5.3 | .2 | 3.8 | .0 | 3.4 | .1 | .5 | 9.3 | .0 | .4 | 1.1 | 35.8 | .0 | .7 | 2.0 | 5.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 20 | 17.2 | 8.2 | .0 | 4.0 | 3.6 | 2.2 | .0 | 5.1 | .1 | 4.2 | .0 | 3.9 | .0 | .4 | 8.9 | .0 | .2 | .9 | 34.1 | .0 | .3 | .8 | 5.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 21 | 19.5 | 8.6 | .0 | 4.1 | 3.5 | 2.6 | .0 | 5.6 | .1 | 4.2 | .0 | 4.1 | .0 | .2 | 8.7 | .0 | .1 | .3 | 32.5 | .0 | .1 | .3 | 5.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 22 | 22.1 | 8.7 | .0 | 4.8 | 3.4 | 3.0 | .0 | 5.6 | .0 | 4.1 | .0 | 4.1 | .0 | .1 | 8.6 | .0 | .1 | .1 | 30.1 | .0 | .0 | .1 | 5.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 23 | 23.5 | 9.0 | .0 | 4.2 | 3.6 | 3.3 | .0 | 5.4 | .0 | 4.1 | .0 | 4.1 | .0 | .1 | 8.4 | .0 | .0 | .0 | 29.1 | .0 | .0 | .0 | 5.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 24 | 24.8 | 8.4 | .0 | 3.8 | 3.8 | 3.8 | .0 | 4.6 | .0 | 4.5 | .0 | 4.1 | .0 | .0 | 8.7 | .0 | .0 | .0 | 28.4 | .0 | .0 | .0 | 5.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 25 | 22.7 | 7.8 | .0 | 3.4 | 2.9 | 4.0 | .0 | 4.1 | 1.5 | 5.3 | .0 | 3.4 | .5 | .4 | 9.4 | .0 | .1 | .3 | 28.6 | .0 | .0 | .2 | 5.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 26 | 20.7 | 7.0 | .0 | 2.9 | 2.3 | 3.9 | .0 | 3.5 | 2.2 | 5.9 | .0 | 3.1 | 1.0 | .8 | 9.6 | .0 | .3 | .6 | 29.8 | .1 | .0 | .6 | 5.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 27 | 18.4 | 6.0 | .0 | 2.5 | 2.0 | 3.8 | .0 | 3.0 | 2.4 | 6.0 | .0 | 2.6 | 1.3 | 1.0 | 10.5 | .0 | .6 | 1.3 | 30.4 | .3 | .3 | 1.3 | 6.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 28 | 16.0 | 5.0 | .0 | 2.2 | 1.9 | 3.6 | .0 | 2.4 | 2.4 | 6.0 | .0 | 2.5 | 1.7 | 1.3 | 10.6 | .0 | 1.0 | 1.9 | 31.7 | .5 | .8 | 1.9 | 6.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 29 | 13.4 | 3.8 | .0 | 2.0 | 1.6 | 3.5 | .0 | 2.1 | 2.8 | 6.3 | .0 | 2.5 | 1.7 | 1.4 | 10.3 | .0 | 1.5 | 2.1 | 32.8 | .7 | 1.8 | 2.8 | 6.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 30 | 10.6 | 3.4 | .0 | 1.6 | 1.3 | 3.6 | .0 | 2.0 | 2.7 | 6.1 | .0 | 2.1 | 1.5 | 1.4 | 10.2 | .0 | 2.1 | 2.2 | 33.8 | .9 | 2.5 | 4.0 | 7.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 31 | 8.4 | 2.8 | .0 | 1.3 | 1.1 | 3.2 | .0 | 1.7 | 2.5 | 5.5 | .0 | 1.8 | 1.6 | 1.6 | 10.6 | .0 | 2.2 | 2.5 | 34.9 | 1.0 | 3.4 | 5.3 | 8.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 32 | 6.5 | 2.3 | .0 | 1.1 | .9 | 2.6 | .0 | 1.9 | 2.3 | 5.4 | .0 | 1.6 | 1.5 | 1.6 | 10.2 | .0 | 2.5 | 2.7 | 36.2 | 1.0 | 3.5 | 6.8 | 9.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 33 | 4.5 | 1.8 | .0 | 1.2 | .8 | 2.3 | .0 | 1.5 | 2.2 | 5.6 | .0 | 1.2 | 1.5 | 1.7 | 9.6 | .0 | 2.5 | 2.7 | 38.6 | 1.1 | 3.9 | 7.2 | 10.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 34 | 3.3 | 1.5 | .0 | 1.0 | .9 | 2.1 | .0 | 1.4 | 2.2 | 5.3 | .0 | 1.1 | 1.1 | 1.7 | 9.2 | .0 | 2.5 | 3.2 | 40.8 | 1.1 | 3.7 | 7.4 | 10.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 35 | 2.4 | 1.4 | .0 | 1.1 | .8 | 1.7 | .0 | 1.5 | 1.6 | 4.9 | .0 | 1.2 | 1.3 | 1.7 | 9.3 | .0 | 2.5 | 3.5 | 42.1 | .9 | 3.8 | 7.0 | 11.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 36 | 2.3 | 1.4 | .0 | 1.3 | 1.1 | 1.8 | .0 | 1.5 | 1.2 | 4.4 | .0 | 1.3 | 1.3 | 1.6 | 9.4 | .0 | 2.2 | 3.4 | 43.5 | .9 | 3.5 | 6.8 | 11.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 37 | 2.5 | 2.1 | .0 | 1.5 | 1.0 | 1.6 | .0 | 1.9 | .9 | 4.1 | .0 | 1.3 | 1.1 | 1.3 | 10.2 | .0 | 2.0 | 2.8 | 43.4 | .9 | 3.4 | 6.9 | 11.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 38 | 3.2 | 2.8 | .0 | 2.0 | 1.1 | 1.5 | .0 | 2.5 | .6 | 4.1 | .0 | 1.7 | .6 | .8 | 9.8 | .0 | 1.6 | 2.3 | 43.2 | .8 | 3.2 | 7.0 | 11.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 39 | 4.4 | 3.3 | .0 | 2.2 | 1.4 | 1.6 | .0 | 3.2 | .4 | 4.2 | .0 | 1.8 | .3 | .8 | 10.0 | .0 | 1.7 | 1.7 | 42.7 | .6 | 2.7 | 6.3 | 10.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 40 | 5.4 | 4.0 | .0 | 3.0 | 1.8 | 1.8 | .0 | 3.7 | .3 | 4.1 | .0 | 2.2 | .3 | .7 | 10.2 | .0 | 1.2 | 1.2 | 42.3 | .5 | 2.0 | 5.3 | 10.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 41 | 6.6 | 4.9 | .0 | 3.3 | 2.3 | 2.2 | .0 | 3.8 | .4 | 4.0 | .0 | 2.8 | .2 | .5 | 9.9 | .0 | 1.1 | 1.0 | 42.6 | .4 | 1.6 | 3.4 | 9.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 42 | 8.0 | 5.5 | .0 | 3.6 | 2.6 | 2.5 | .0 | 4.4 | .2 | 4.0 | .0 | 3.2 | .1 | .4 | 10.1 | .0 | .6 | .8 | 41.3 | .2 | 1.0 | 2.9 | 8.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 43 | 9.7 | 6.7 | .0 | 3.9 | 2.6 | 2.9 | .0 | 4.7 | .1 | 4.3 | .0 | 3.7 | .1 | .3 | 9.7 | .0 | .4 | .8 | 39.6 | .1 | .6 | 1.7 | 8.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 44 | 11.6 | 7.6 | .0 | 4.2 | 2.7 | 3.2 | .0 | 4.9 | .1 | 4.6 | .0 | 3.9 | .1 | .2 | 9.9 | .0 | .1 | .6 | 37.9 | .1 | .3 | .9 | 7.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 45 | 13.4 | 8.1 | .0 | 4.2 | 3.0 | 3.7 | .0 | 5.4 | .1 | 4.9 | .0 | 4.3 | .1 | .0 | 9.6 | .0 | .1 | .4 | 35.5 | .0 | .1 | .4 | 6.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 46 | 15.2 | 8.6 | .0 | 4.4 | 3.0 | 4.2 | .0 | 5.5 | .0 | 4.8 | .0 | 4.6 | .0 | .1 | 9.1 | .0 | .0 | .1 | 33.9 | .0 | .0 | .1 | 6.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 47 | 16.9 | 9.0 | .0 | 4.3 | 3.1 | 4.5 | .0 | 6.0 | .0 | 4.8 | .0 | 4.4 | .0 | .0 | 8.9 | .0 | .0 | .0 | 31.9 | .0 | .0 | .0 | 6.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 48 | 18.1 | 9.0 | .0 | 4.1 | 3.2 | 4.8 | .0 | 5.5 | .0 | 5.3 | .0 | 4.5 | .1 | .0 | 8.6 | .0 | .0 | .0 | 31.2 | .0 | .0 | .0 | 5.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 49 | 17.2 | 8.1 | .0 | 4.2 | 2.6 | 4.9 | .0 | 4.5 | 1.3 | 5.8 | .0 | 4.2 | .3 | .7 | 9.3 | .0 | .0 | .4 | 30.5 | .0 | .0 | .1 | 5.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 50 | 15.6 | 7.5 | .0 | 3.6 | 2.3 | 4.9 | .0 | 3.9 | 1.7 | 5.9 | .0 | 4.0 | .9 | 1.1 | 9.8 | .0 | .1 | .9 | 31.3 | .1 | .2 | .4 | 5.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 51 | 14.2 | 6.4 | .0 | 3.3 | 1.9 | 5.1 | .0 | 3.2 | 2.0 | 6.3 | .0 | 3.8 | 1.1 | 1.5 | 9.5 | .0 | .4 | 1.6 | 32.1 | .2 | .4 | 1.0 | 6.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 52 | 12.7 | 5.1 | .0 | 3.3 | 1.7 | 4.9 | .0 | 2.6 | 2.1 | 6.0 | .0 | 3.3 | 1.3 | 1.7 | 9.8 | .0 | 1.0 | 2.0 | 33.3 | .3 | .7 | 2.0 | 6.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 53 | 11.2 | 4.4 | .0 | 2.8 | 1.2 | 4.6 | .0 | 2.1 | 2.1 | 6.3 | .0 | 3.2 | 1.2 | 1.8 | 9.8 | .0 | 1.2 | 2.2 | 33.3 | .5 | 1.6 | 2.9 | 7.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 54 | 9.3 | 3.9 | .0 | 2.5 | .9 | 4.3 | .0 | 1.7 | 2.4 | 6.5 | .0 | 2.9 | 1.3 | 1.9 | 9.3 | .0 | 1.7 | 2.0 | 34.5 | .6 | 2.1 | 4.3 | 7.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 55 | 8.3 | 3.2 | .0 | 2.2 | .8 | 3.8 | .0 | 1.3 | 2.3 | 6.1 | .0 | 2.1 | 1.3 | 2.0 | 10.0 | .0 | 1.7 | 2.3 | 35.2 | .7 | 3.0 | 5.4 | 8.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 56 | 6.2 | 2.7 | .0 | 1.6 | .7 | 3.4 | .0 | 1.2 | 2.3 | 6.0 | .0 | 1.9 | 1.5 | 2.1 | 9.3 | .0 | 2.3 | 2.6 | 36.8 | .7 | 3.0 | 6.2 | 9.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 57 | 4.8 | 2.2 | .0 | 1.4 | .5 | 2.9 | .0 | 1.1 | 2.1 | 5.6 | .0 | 1.4 | 1.3 | 2.2 | 9.3 | .0 | 2.4 | 2.8 | 39.0 | .8 | 3.5 | 6.6 | 10.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 58 | 3.5 | 1.7 | .0 | 1.5 | .8 | 2.6 | .0 | 1.1 | 1.8 | 5.2 | .0 | 1.3 | 1.2 | 2.0 | 9.5 | .0 | 2.2 | 3.2 | 40.4 | .9 | 3.4 | 6.9 | 10.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 59 | 2.5 | 1.7 | .0 | 1.3 | .7 | 2.5 | .0 | 1.1 | 1.6 | 4.5 | .0 | 1.1 | 1.4 | 1.9 | 10.2 | .0 | 2.4 | 3.0 | 41.7 | .8 | 3.2 | 7.4 | 11.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 60 | 2.1 | 1.8 | .0 | 1.6 | .6 | 2.4 | .0 | 1.3 | 1.1 | 4.6 | .0 | 1.3 | 1.2 | 1.7 | 10.2 | .0 | 2.5 | 2.9 | 41.8 | .8 | 3.1 | 7.2 | 11.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 61 | 2.5 | 2.0 | .0 | 1.9 | .8 | 2.1 | .0 | 1.5 | .7 | 4.3 | .0 | 1.7 | 1.0 | 1.6 | 10.3 | .0 | 2.1 | 2.4 | 42.8 | .7 | 3.1 | 6.8 | 11.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 62 | 3.4 | 2.6 | .0 | 2.3 | 1.1 | 1.9 | .0 | 2.2 | .6 | 4.1 | .0 | 2.2 | .6 | 1.3 | 10.5 | .0 | 1.9 | 2.1 | 42.2 | .5 | 2.9 | 6.0 | 11.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 63 | 4.8 | 3.0 | .0 | 2.7 | 1.7 | 1.5 | .0 | 2.7 | .4 | 4.5 | .0 | 2.6 | .4 | .8 | 10.4 | .0 | 1.8 | 1.6 | 41.4 | .4 | 2.4 | 5.4 | 11.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 64 | 5.9 | 4.1 | .0 | 3.2 | 1.9 | 1.6 | .0 | 3.8 | .4 | 4.4 | .0 | 3.1 | .1 | .7 | 10.2 | .0 | 1.5 | 1.5 | 40.7 | .3 | 2.3 | 4.4 | 10.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 65 | 7.9 | 4.7 | .0 | 3.7 | 2.3 | 1.7 | .0 | 3.4 | .4 | 4.4 | .0 | 3.8 | .1 | .6 | 10.0 | .0 | 1.3 | 1.2 | 38.9 | .2 | 1.4 | 3.7 | 10.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 66 | 9.7 | 5.2 | .0 | 4.1 | 2.5 | 2.0 | .0 | 3.9 | .3 | 4.5 | .0 | 4.3 | .1 | .5 | 10.3 | .0 | 1.1 | 1.1 | 37.5 | .2 | .8 | 2.5 | 9.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 67 | 11.4 | 6.0 | .0 | 4.8 | 2.7 | 2.4 | .0 | 4.2 | .2 | 4.8 | .0 | 4.8 | .1 | .4 | 9.8 | .0 | .6 | .9 | 35.6 | .3 | .7 | 1.6 | 9.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 68 | 13.3 | 7.1 | .0 | 5.1 | 2.5 | 2.8 | .0 | 4.4 | .1 | 4.9 | .0 | 4.8 | .1 | .2 | 9.5 | .0 | .4 | .7 | 34.1 | .1 | .4 | 1.0 | 8.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 69 | 15.2 | 8.0 | .0 | 5.6 | 2.8 | 3.3 | .0 | 5.0 | .1 | 4.8 | .0 | 4.6 | .1 | .3 | 9.3 | .0 | .3 | .5 | 31.9 | .0 | .2 | .3 | 7.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 70 | 17.3 | 8.3 | .0 | 5.6 | 2.7 | 3.7 | .0 | 5.0 | .0 | 4.9 | .0 | 5.0 | .1 | .1 | 8.8 | .0 | .1 | .2 | 31.0 | .0 | .0 | .1 | 7.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 71 | 18.8 | 8.8 | .0 | 5.6 | 2.7 | 4.4 | .0 | 4.3 | .1 | 4.8 | .0 | 5.0 | .0 | .0 | 8.7 | .0 | .1 | .1 | 29.6 | .0 | .0 | .0 | 7.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 72 | 20.2 | 8.2 | .0 | 5.3 | 2.5 | 4.9 | .0 | 4.1 | .1 | 5.2 | .0 | 5.1 | .1 | .0 | 8.6 | .0 | .0 | .1 | 29.0 | .0 | .0 | .1 | 6.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |

**TABLE E.3:** Percentage frequency of occurrence of different atmospheric conditions ij for a start condition of 41 (72 hour period, 5 years of data for St. John Airport, elevated release, downwind distance 1 km).

| HR | 41 | 31 | 51 | 42 | 21 | 32 | 52 | 43 | 22 | 11 | 33 | 53 | 44 | 23 | 12 | 34 | 54 | 45 | 24 | 13 | 35 | 55 | 25 | 14 | 15 | 61 | 62 | 63 | 64 | 65 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 51.9 | 1.0 | .0 | 21.0 | .2 | .4 | .8 | 12.0 | .1 | .0 | .1 | .9 | 4.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 4.7 | 1.0 | .0 | .0 | .0 |
| 2 | 38.0 | 2.8 | .0 | 20.3 | .4 | .7 | .8 | 15.0 | .0 | .2 | .4 | 1.3 | 10.6 | .0 | .0 | .1 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.6 | 2.0 | .1 | .0 | .0 |
| 3 | 29.7 | 2.8 | .0 | 19.2 | 1.0 | 1.3 | .6 | 18.1 | .7 | .1 | .3 | 1.5 | 14.7 | .3 | .0 | .6 | .3 | .3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.9 | 1.3 | .4 | .0 | .0 |
| 4 | 23.8 | 2.9 | .0 | 17.0 | 1.0 | 1.4 | .7 | 18.5 | .9 | .2 | 1.1 | 1.6 | 20.0 | .6 | .0 | .9 | .4 | .7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.4 | 1.6 | .3 | .0 | .0 |
| 5 | 18.7 | 3.0 | .0 | 16.3 | 1.2 | 2.0 | .8 | 17.2 | 1.4 | .3 | 1.3 | 2.3 | 23.7 | 1.2 | .0 | 2.0 | .6 | .8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 5.4 | 1.7 | .2 | .0 | .0 |
| 6 | 14.7 | 2.6 | .0 | 13.8 | 1.6 | 1.6 | .9 | 18.9 | 1.6 | .7 | 1.2 | 1.2 | 26.8 | 1.9 | .0 | 2.5 | .6 | 1.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 5.2 | 1.9 | .0 | .0 | .0 |
| 7 | 12.2 | 2.5 | .0 | 12.2 | .8 | 2.0 | 1.0 | 20.5 | 2.2 | .5 | 1.0 | 1.2 | 30.0 | 1.7 | .0 | 3.1 | .6 | 1.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 4.6 | 1.3 | .0 | .0 | .0 |
| 8 | 10.3 | 2.5 | .0 | 11.1 | .9 | 1.7 | .7 | 20.7 | 1.2 | .6 | 1.2 | 1.3 | 34.6 | 2.4 | .0 | 3.0 | .5 | 2.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 3.6 | .7 | .0 | .0 | .0 |
| 9 | 9.0 | 2.2 | .0 | 10.7 | .8 | 1.9 | .8 | 20.3 | .9 | .1 | 2.1 | 1.0 | 35.3 | 2.6 | .0 | 3.3 | .7 | 3.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.9 | 1.0 | 1.2 | .0 | .0 |
| 10 | 7.1 | 2.0 | .0 | 11.3 | .8 | 1.6 | .8 | 18.0 | .9 | .4 | 1.8 | 1.6 | 38.5 | 2.6 | .0 | 2.9 | .7 | 3.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 3.4 | .9 | 1.1 | .0 | .0 |
| 11 | 6.2 | 2.3 | .0 | 10.7 | .8 | 1.4 | .7 | 17.7 | 1.2 | .4 | 1.8 | 2.0 | 39.2 | 2.4 | .0 | 2.8 | .8 | 3.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 3.3 | 1.4 | 1.0 | .0 | .0 |
| 12 | 6.1 | 1.5 | .0 | 10.0 | .4 | 1.2 | 1.1 | 15.9 | 1.0 | .3 | 1.8 | 2.8 | 40.3 | 2.4 | .0 | 3.0 | 1.1 | 4.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 3.7 | 1.5 | 1.3 | .0 | .0 |
| 13 | 6.5 | 1.6 | .0 | 9.0 | .0 | 1.0 | 1.9 | 15.3 | .8 | .2 | 2.2 | 3.2 | 39.0 | 1.7 | .0 | 3.2 | 1.0 | 5.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 4.2 | 2.7 | 1.5 | .0 | .0 |
| 14 | 5.6 | .8 | .0 | 9.3 | .0 | 1.9 | 1.4 | 15.4 | 1.0 | .0 | 1.3 | 3.2 | 38.6 | 1.3 | .0 | 3.6 | 1.6 | 5.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.1 | 2.4 | 1.9 | .0 | .0 |
| 15 | 4.9 | 1.2 | .0 | 10.7 | .1 | .8 | 1.4 | 13.0 | .8 | .1 | .9 | 3.1 | 38.5 | 1.2 | .0 | 3.1 | 1.5 | 5.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 7.5 | 2.8 | 1.8 | .0 | .0 |
| 16 | 4.8 | 1.0 | .0 | 9.1 | .1 | .8 | .9 | 14.8 | .4 | .1 | .8 | 2.9 | 39.0 | 1.3 | .0 | 1.8 | 2.2 | 5.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 7.8 | 4.0 | 1.9 | .0 | .0 |
| 17 | 5.5 | 1.0 | .0 | 8.7 | .1 | .8 | 1.7 | 12.8 | .5 | .2 | .8 | 3.4 | 38.9 | .4 | .0 | 1.6 | 2.2 | 6.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 9.5 | 4.1 | 1.7 | .0 | .0 |
| 18 | 5.7 | .8 | .0 | 7.5 | .0 | .6 | 1.2 | 13.4 | .3 | .1 | .8 | 3.1 | 37.9 | .3 | .0 | 2.2 | 2.4 | 6.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 10.6 | 5.1 | 2.1 | .0 | .0 |
| 19 | 5.7 | .8 | .0 | 6.9 | .1 | .5 | 2.3 | 13.0 | .4 | .1 | .6 | 2.5 | 37.3 | .5 | .0 | 1.3 | 2.3 | 6.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 11.9 | 4.6 | 2.5 | .0 | .0 |
| 20 | 6.5 | .7 | .0 | 7.4 | .0 | .3 | 1.8 | 12.5 | .4 | .2 | .0 | 2.7 | 35.5 | .5 | .0 | 1.5 | 2.7 | 7.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 13.1 | 5.3 | 1.8 | .0 | .0 |
| 21 | 6.9 | 1.1 | .0 | 5.8 | .0 | .3 | 1.5 | 13.7 | .0 | .2 | .2 | 2.9 | 34.7 | .4 | .0 | 1.2 | 3.1 | 7.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 14.3 | 4.4 | 2.3 | .0 | .0 |
| 22 | 7.3 | 1.1 | .0 | 6.0 | .2 | .6 | 1.2 | 12.1 | .1 | .0 | .1 | 2.5 | 35.6 | .5 | .0 | 1.3 | 3.5 | 6.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 15.4 | 4.1 | 2.1 | .0 | .0 |
| 23 | 7.5 | 1.9 | .0 | 5.7 | .2 | .4 | 1.5 | 12.3 | .4 | .1 | .0 | 2.2 | 34.0 | .8 | .0 | 1.4 | 3.5 | 7.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 15.3 | 3.5 | 2.3 | .0 | .0 |
| 24 | 7.4 | 2.6 | .0 | 6.2 | .1 | .5 | 1.5 | 13.3 | .4 | .1 | .6 | 1.9 | 33.3 | .8 | .0 | 1.1 | 3.1 | 7.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 12.7 | 4.1 | 3.1 | .0 | .0 |
| 25 | 6.8 | 2.8 | .0 | 6.4 | .3 | .7 | 1.3 | 13.9 | .4 | .0 | .8 | 1.8 | 31.4 | .3 | .0 | 2.1 | 3.8 | 7.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 12.7 | 4.4 | 2.4 | .0 | .0 |
| 26 | 6.5 | 2.6 | .0 | 7.4 | .3 | .9 | 1.3 | 13.1 | .5 | .0 | .9 | 2.2 | 31.6 | .4 | .0 | 2.3 | 3.3 | 8.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 12.0 | 4.1 | 2.4 | .0 | .0 |
| 27 | 6.5 | 3.1 | .0 | 7.6 | .4 | 1.4 | 1.4 | 12.6 | .7 | .1 | 1.1 | 1.5 | 31.6 | .8 | .0 | 2.7 | 3.0 | 9.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 10.5 | 3.7 | 2.1 | .0 | .0 |
| 28 | 5.9 | 2.5 | .0 | 7.0 | .8 | 1.6 | 1.3 | 13.2 | .7 | .2 | 1.4 | .9 | 32.3 | 1.8 | .0 | 2.8 | 2.8 | 8.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 9.5 | 4.3 | 2.1 | .0 | .0 |
| 29 | 5.7 | 2.5 | .0 | 6.8 | .9 | 1.1 | .7 | 12.3 | .9 | .4 | 1.7 | 1.5 | 33.2 | 2.0 | .0 | 3.7 | 2.3 | 9.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 9.5 | 3.4 | 2.1 | .0 | .0 |
| 30 | 4.1 | 2.3 | .0 | 7.2 | 1.0 | 1.3 | .8 | 11.6 | 1.2 | .6 | 2.1 | 1.8 | 34.9 | 2.4 | .0 | 4.0 | 2.8 | 9.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 9.0 | 3.4 | 1.5 | .0 | .0 |
| 31 | 3.5 | 2.0 | .0 | 7.1 | .9 | 1.2 | .7 | 11.1 | 1.8 | .4 | 1.7 | 1.8 | 37.1 | 2.7 | .0 | 4.0 | 2.7 | 8.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 8.5 | 3.3 | 1.3 | .0 | .0 |
| 32 | 3.4 | 2.5 | .0 | 5.6 | .7 | 1.7 | 1.2 | 10.7 | 2.1 | .3 | 2.3 | 1.6 | 37.6 | 2.4 | .0 | 4.9 | 2.5 | 8.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 7.9 | 3.1 | 1.6 | .0 | .0 |
| 33 | 2.8 | 2.5 | .0 | 5.6 | 1.1 | 1.8 | .8 | 10.7 | 1.5 | .3 | 2.2 | 1.1 | 38.5 | 2.6 | .0 | 5.5 | 2.4 | 8.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 7.2 | 3.3 | 1.9 | .0 | .0 |
| 34 | 3.1 | 2.5 | .0 | 6.0 | 1.6 | 1.7 | .7 | 11.8 | 1.6 | .6 | 1.7 | 1.3 | 38.2 | 2.2 | .0 | 5.8 | 2.6 | 7.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.3 | 2.8 | 1.6 | .0 | .0 |
| 35 | 3.7 | 2.0 | .0 | 6.8 | 1.3 | 2.1 | 1.0 | 10.2 | 1.3 | .6 | 1.6 | 1.8 | 39.1 | 2.5 | .0 | 5.9 | 2.9 | 6.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 5.8 | 3.1 | 1.5 | .0 | .0 |
| 36 | 2.9 | 1.5 | .0 | 6.8 | .8 | 1.8 | 1.0 | 12.3 | 1.7 | .5 | 1.2 | 2.0 | 36.3 | 2.1 | .0 | 6.3 | 2.7 | 7.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.6 | 3.9 | 2.3 | .0 | .0 |
| 37 | 3.0 | 1.1 | .0 | 7.3 | .8 | 1.4 | 1.0 | 11.9 | 1.6 | .2 | 1.1 | 3.3 | 36.3 | 2.5 | .0 | 4.8 | 3.3 | 7.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 7.2 | 4.7 | 1.2 | .0 | .0 |
| 38 | 2.6 | 1.1 | .0 | 7.0 | .5 | 1.2 | 1.8 | 10.7 | .9 | .3 | 1.4 | 3.9 | 35.8 | 2.7 | .0 | 4.4 | 2.8 | 7.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 8.6 | 5.1 | 1.8 | .0 | .0 |
| 39 | 2.9 | .8 | .0 | 6.6 | .4 | 1.3 | 1.5 | 11.5 | .8 | .3 | 1.2 | 3.2 | 33.3 | 2.0 | .0 | 4.9 | 3.4 | 7.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 10.0 | 5.4 | 2.9 | .0 | .0 |
| 40 | 2.9 | .7 | .0 | 7.2 | .4 | .9 | 2.0 | 11.1 | .8 | .3 | 1.6 | 4.3 | 32.2 | 1.9 | .0 | 4.5 | 3.2 | 7.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 11.4 | 4.6 | 2.8 | .0 | .0 |
| 41 | 4.3 | .6 | .0 | 6.7 | .3 | .8 | 1.9 | 10.0 | .6 | .2 | 1.2 | 3.9 | 31.6 | 1.7 | .0 | 4.5 | 3.8 | 6.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 12.6 | 5.5 | 3.1 | .0 | .0 |
| 42 | 4.3 | .6 | .0 | 6.1 | .2 | .7 | 1.9 | 9.7 | .9 | .1 | .8 | 4.8 | 31.2 | 1.5 | .0 | 4.0 | 3.9 | 6.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 14.4 | 5.6 | 3.0 | .0 | .0 |
| 43 | 4.1 | .4 | .0 | 5.9 | .4 | .6 | 1.7 | 10.5 | 1.0 | .1 | .9 | 4.5 | 30.9 | 1.3 | .0 | 2.7 | 4.3 | 5.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 16.3 | 5.7 | 2.9 | .0 | .0 |
| 44 | 3.4 | .5 | .0 | 6.5 | .1 | .6 | 1.6 | 11.5 | 1.1 | .1 | .8 | 3.8 | 27.9 | 1.1 | .0 | 2.1 | 5.1 | 6.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 18.2 | 5.8 | 3.3 | .0 | .0 |
| 45 | 3.5 | .7 | .0 | 6.1 | .2 | .6 | 1.7 | 12.4 | .8 | .0 | .8 | 3.3 | 28.5 | .9 | .0 | 2.0 | 4.7 | 5.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 19.1 | 5.7 | 3.8 | .0 | .0 |
| 46 | 4.0 | 1.5 | .0 | 6.3 | .1 | .6 | 2.2 | 11.8 | .6 | .1 | 1.4 | 3.2 | 27.4 | .8 | .0 | 1.8 | 4.2 | 5.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 18.5 | 6.4 | 4.0 | .0 | .0 |
| 47 | 4.3 | 2.1 | .0 | 5.4 | .5 | .5 | 2.0 | 12.2 | .7 | .1 | .9 | 2.8 | 27.5 | 1.0 | .0 | 1.9 | 4.1 | 5.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 17.8 | 7.4 | 3.7 | .0 | .0 |
| 48 | 4.3 | 2.4 | .0 | 5.4 | .9 | .8 | 2.2 | 11.5 | .5 | .0 | 1.1 | 2.9 | 28.0 | .9 | .0 | 2.3 | 3.8 | 5.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 17.1 | 7.2 | 3.8 | .0 | .0 |
| 49 | 4.1 | 2.4 | .0 | 5.9 | 1.1 | 1.3 | 1.6 | 11.0 | .8 | .2 | 1.8 | 2.7 | 29.2 | 1.0 | .0 | 2.4 | 3.7 | 4.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 15.6 | 6.8 | 3.8 | .0 | .0 |
| 50 | 4.4 | 2.7 | .0 | 7.1 | .8 | 1.6 | 1.4 | 11.0 | 1.1 | .2 | 1.7 | 2.4 | 30.2 | 1.7 | .0 | 2.9 | 3.2 | 4.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 14.0 | 5.8 | 3.3 | .0 | .0 |
| 51 | 4.3 | 3.1 | .0 | 7.5 | 1.1 | 1.4 | 1.1 | 9.0 | 2.0 | .2 | 2.2 | 2.1 | 31.2 | 2.7 | .0 | 3.5 | 3.0 | 5.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 12.2 | 5.4 | 3.0 | .0 | .0 |
| 52 | 4.5 | 2.9 | .0 | 7.4 | 1.3 | 1.8 | .8 | 10.0 | 1.7 | .2 | 1.8 | 2.0 | 31.1 | 2.9 | .0 | 5.3 | 2.5 | 5.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 10.7 | 5.2 | 2.7 | .0 | .0 |
| 53 | 4.1 | 2.9 | .0 | 6.5 | 1.5 | 1.7 | 1.2 | 10.6 | 2.1 | 1.1 | 1.9 | 2.7 | 31.8 | 2.7 | .0 | 6.1 | 1.9 | 5.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 8.8 | 4.1 | 2.7 | .0 | .0 |
| 54 | 3.3 | 2.7 | .0 | 5.7 | 1.0 | 1.6 | 1.4 | 12.3 | 2.3 | 1.2 | 1.6 | 2.1 | 34.1 | 3.0 | .0 | 6.3 | 1.5 | 5.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 7.5 | 4.1 | 2.5 | .0 | .0 |
| 55 | 3.2 | 2.5 | .0 | 5.7 | 1.2 | .9 | 1.1 | 11.9 | 2.6 | .8 | 2.5 | 2.0 | 33.4 | 4.1 | .0 | 6.9 | 1.9 | 6.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 7.0 | 3.5 | 2.5 | .0 | .0 |
| 56 | 2.5 | 2.0 | .0 | 5.7 | 1.2 | 1.1 | 1.5 | 11.9 | 2.5 | .9 | 2.5 | 1.4 | 34.3 | 4.1 | .0 | 6.5 | 1.5 | 7.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 7.2 | 3.1 | 2.5 | .0 | .0 |
| 57 | 2.8 | 1.7 | .0 | 5.6 | 1.2 | 1.6 | .9 | 10.8 | 2.4 | .8 | 2.6 | 2.3 | 35.3 | 3.8 | .0 | 7.4 | 1.4 | 7.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.5 | 3.2 | 2.0 | .0 | .0 |
| 58 | 2.7 | 1.8 | .0 | 4.9 | 1.2 | 1.5 | .8 | 12.1 | 2.1 | .5 | 2.5 | 2.3 | 37.0 | 3.3 | .0 | 6.3 | .8 | 8.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.8 | 2.6 | 2.0 | .0 | .0 |
| 59 | 2.2 | 1.4 | .0 | 5.7 | .8 | 1.1 | 1.7 | 12.1 | 1.8 | .6 | 2.5 | 1.9 | 36.7 | 3.8 | .0 | 6.1 | 1.8 | 8.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.4 | 2.9 | 2.2 | .0 | .0 |
| 60 | 2.3 | 1.2 | .0 | 5.4 | .5 | .9 | 1.9 | 13.1 | 1.8 | .7 | 1.4 | 2.3 | 36.3 | 3.3 | .0 | 4.8 | 1.7 | 9.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 7.1 | 3.4 | 2.9 | .0 | .0 |
| 61 | 2.5 | .9 | .0 | 5.7 | .8 | .8 | 1.3 | 11.4 | 1.8 | .6 | 2.3 | 2.7 | 38.1 | 2.3 | .0 | 4.6 | 1.8 | 7.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 7.4 | 4.6 | 2.8 | .0 | .0 |
| 62 | 2.8 | .9 | .0 | 5.9 | .3 | .9 | 2.3 | 11.6 | 1.8 | .6 | 1.2 | 2.4 | 37.7 | 2.1 | .0 | 4.1 | 2.4 | 7.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 8.6 | 3.9 | 3.3 | .0 | .0 |
| 63 | 3.1 | .6 | .0 | 6.2 | .3 | .8 | 1.6 | 12.2 | 1.2 | .4 | 1.5 | 3.0 | 36.6 | 1.5 | .0 | 4.0 | 2.6 | 7.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 9.3 | 4.2 | 3.4 | .0 | .0 |
| 64 | 3.5 | .5 | .0 | 6.4 | .2 | .6 | 2.5 | 12.1 | 1.2 | .1 | .9 | 3.1 | 36.9 | .8 | .0 | 3.2 | 3.4 | 7.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 10.1 | 4.8 | 3.3 | .0 | .0 |
| 65 | 3.1 | .6 | .0 | 6.5 | .1 | .4 | 2.5 | 10.7 | 1.1 | .0 | 1.0 | 3.9 | 37.0 | .6 | .0 | 2.5 | 3.4 | 6.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 11.3 | 5.4 | 3.9 | .0 | .0 |
| 66 | 3.7 | .6 | .0 | 5.2 | .3 | .3 | 2.5 | 9.6 | .7 | .1 | .8 | 4.4 | 36.0 | .8 | .0 | 1.9 | 3.8 | 7.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 12.6 | 6.0 | 3.7 | .0 | .0 |
| 67 | 4.0 | .7 | .0 | 4.6 | .3 | .3 | 2.4 | 10.0 | 1.0 | .0 | 1.0 | 4.3 | 34.8 | .3 | .0 | 1.4 | 3.9 | 6.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 14.6 | 6.5 | 3.6 | .0 | .0 |
| 68 | 3.8 | .7 | .0 | 5.7 | .4 | .7 | 2.2 | 10.1 | .4 | .0 | .6 | 4.1 | 32.6 | .5 | .0 | 1.0 | 4.7 | 6.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 16.4 | 6.3 | 3.5 | .0 | .0 |
| 69 | 4.1 | 1.2 | .0 | 5.7 | .3 | .6 | 3.5 | 9.5 | .3 | .2 | .3 | 3.3 | 32.2 | .5 | .0 | 1.0 | 5.2 | 5.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 17.0 | 6.1 | 3.1 | .0 | .0 |
| 70 | 5.1 | 1.3 | .0 | 5.5 | .6 | .6 | 2.6 | 10.3 | .4 | .2 | .6 | 3.0 | 31.3 | .5 | .0 | 1.1 | 4.6 | 5.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 16.3 | 6.7 | 3.7 | .0 | .0 |
| 71 | 5.5 | 1.5 | .0 | 4.9 | .7 | .4 | 2.5 | 9.3 | .8 | .1 | .7 | 3.5 | 32.4 | .4 | .0 | 1.5 | 3.5 | 6.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 16.3 | 5.8 | 3.8 | .0 | .0 |
| 72 | 5.4 | 1.6 | .0 | 5.6 | .6 | .7 | 1.4 | 10.0 | .7 | .2 | 1.1 | 3.6 | 32.1 | .8 | .0 | 1.6 | 3.8 | 5.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 16.0 | 6.0 | 3.2 | .0 | .0 |

TABLE E.4: Percentage frequency of occurrence of different atmospheric conditions ij for a start condition of 61 (72 hour period, 5 years of data for St. John Airport, elevated release, downwind distance 3 km).

| [illegible] | 51 | 61 | 41 | 52 | 62 | 31 | 42 | 53 | 63 | 32 | 43 | 71 | 54 | 64 | 33 | 44 | 72 | 55 | 11 | 65 | 34 | 45 | 23 | 12 | 35 | 24 | 13 | 25 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | .0 | 68.2 | 2.6 | 2.0 | 11.3 | 4.0 | 1.5 | 2.3 | 2.5 | .0 | 1.0 | 1.6 | .0 | .0 | .2 | .9 | .3 | .0 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 2 | .0 | 56.6 | 3.0 | 2.4 | 10.4 | 5.0 | 3.0 | 2.5 | 2.7 | 1.6 | 2.1 | 3.1 | .9 | .0 | .7 | 2.6 | .9 | .0 | .3 | .0 | .5 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 3 | .0 | 47.6 | 4.1 | 2.2 | 9.7 | 6.0 | 4.1 | 2.1 | 2.4 | 2.2 | 3.4 | 3.8 | 1.2 | .0 | 1.9 | 4.5 | 1.9 | .0 | .0 | .0 | 1.4 | .1 | .5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 4 | .0 | 39.1 | 4.0 | 1.6 | 8.3 | 6.0 | 4.4 | 2.3 | 2.5 | 2.4 | 4.0 | 4.3 | 1.5 | .0 | 3.1 | 7.1 | 2.7 | .0 | 1.2 | .0 | 2.7 | .3 | 1.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 5 | .0 | 32.1 | 4.1 | 1.4 | 7.2 | 6.0 | 4.5 | 2.0 | 2.0 | 2.5 | 5.9 | 4.3 | 1.1 | .0 | 3.5 | 10.0 | 3.4 | .0 | 1.6 | .0 | 4.6 | .6 | 3.2 | .0 | .0 | .0 | .9 | .0 | .0 | .0 |
| 6 | .0 | 25.2 | 3.5 | 1.1 | 5.8 | 5.7 | 5.2 | 2.1 | 1.5 | 2.7 | 6.4 | 4.1 | 1.4 | .0 | 3.6 | 13.6 | 3.9 | .0 | 2.0 | .0 | 6.3 | 1.3 | 4.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 7 | .0 | 19.3 | 3.4 | .8 | 4.9 | 5.3 | 5.2 | 1.0 | 1.3 | 2.7 | 6.5 | 4.1 | 1.2 | .0 | 4.0 | 17.0 | 4.2 | .0 | 1.9 | .0 | 8.2 | 2.6 | 5.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 8 | .0 | 14.3 | 2.9 | .9 | 4.1 | 5.1 | 5.3 | 1.5 | 1.1 | 2.9 | 6.7 | 3.8 | 1.2 | .0 | 4.2 | 21.6 | 4.1 | .0 | 1.8 | .0 | 9.1 | 3.3 | 6.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 9 | .0 | 10.7 | 2.3 | .7 | 3.8 | 4.6 | 4.9 | 1.6 | 1.1 | 3.0 | 7.2 | 3.6 | .9 | .0 | 4.1 | 26.0 | 4.4 | .0 | 1.7 | .0 | 10.3 | 4.1 | 6.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 10 | .0 | 7.6 | 1.8 | .7 | 2.7 | 3.7 | 4.5 | 1.2 | 1.1 | 2.9 | 8.3 | 3.3 | .8 | .0 | 4.3 | 29.1 | 4.0 | .0 | 1.6 | .0 | 11.3 | 5.3 | 5.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 11 | .0 | 5.3 | 1.5 | .8 | 2.3 | 2.9 | 4.2 | 1.3 | 1.1 | 2.6 | 8.5 | 3.2 | .7 | .0 | 4.6 | 33.5 | 3.9 | .0 | 1.4 | .0 | 11.0 | 5.7 | 5.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 12 | .0 | 4.3 | 1.3 | 1.2 | 2.4 | 1.8 | 4.0 | 1.5 | 1.4 | 2.3 | 8.8 | 2.7 | 1.0 | .0 | 4.3 | 35.9 | 3.6 | .0 | 1.3 | .0 | 10.4 | 6.3 | 5.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 13 | .0 | 4.3 | 1.1 | 1.1 | 2.7 | 1.3 | 4.0 | 1.9 | 1.5 | 1.8 | 8.8 | 2.0 | 1.1 | .0 | 3.3 | 38.0 | 3.3 | .0 | 1.3 | .0 | 9.5 | 6.7 | 5.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 14 | .0 | 4.9 | 1.2 | 1.6 | 3.0 | 1.0 | 3.7 | 2.9 | 2.0 | 1.2 | 8.4 | 1.3 | 1.5 | .0 | 2.8 | 40.4 | 2.4 | .0 | 1.3 | .0 | 8.7 | 6.7 | 4.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 15 | .0 | 6.5 | 1.4 | 2.2 | 3.8 | .8 | 3.6 | 3.6 | 2.1 | .9 | 8.4 | .7 | 1.8 | .0 | 2.7 | 40.2 | 2.3 | .0 | 1.1 | .0 | 7.4 | 7.0 | 3.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 16 | .0 | 8.5 | 1.6 | 2.4 | 4.4 | .7 | 3.7 | 4.2 | 2.7 | .8 | 8.5 | .3 | 2.3 | .0 | 2.1 | 39.6 | 1.5 | .0 | .7 | .0 | 5.7 | 7.0 | 3.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 17 | .0 | 10.5 | 1.8 | 2.9 | 5.5 | .5 | 3.7 | 4.6 | 3.1 | .7 | 8.9 | .2 | 2.7 | .0 | 2.0 | 38.2 | 1.1 | .0 | .4 | .0 | 4.6 | 6.3 | 2.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 18 | .0 | 12.9 | 1.8 | 3.1 | 6.5 | .4 | 4.2 | 4.9 | 3.3 | .4 | 9.2 | .1 | 2.9 | .0 | 1.5 | 37.2 | .8 | .0 | .1 | .0 | 3.2 | 6.2 | 1.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 19 | .0 | 15.0 | 2.0 | 3.3 | 7.0 | .2 | 3.8 | 5.3 | 4.0 | .5 | 9.3 | .1 | 3.4 | .0 | 1.1 | 35.8 | .4 | .0 | .0 | .0 | 2.0 | 5.9 | .7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 20 | .0 | 17.2 | 2.2 | 3.6 | 8.2 | .1 | 4.2 | 5.1 | 4.0 | .4 | 8.9 | .0 | 3.9 | .0 | .9 | 34.1 | .2 | .0 | .0 | .0 | .8 | 5.8 | .3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 21 | .0 | 19.5 | 2.6 | 3.5 | 8.6 | .1 | 4.2 | 5.6 | 4.1 | .2 | 8.7 | .0 | 4.1 | .0 | .3 | 32.5 | .1 | .0 | .0 | .0 | .3 | 5.5 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 22 | .0 | 22.1 | 3.0 | 3.4 | 8.7 | .0 | 4.1 | 5.6 | 4.0 | .1 | 8.6 | .0 | 4.1 | .0 | .1 | 30.1 | .1 | .0 | .0 | .0 | .1 | 5.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 23 | .0 | 23.5 | 3.3 | 3.6 | 9.0 | .0 | 4.1 | 5.4 | 4.2 | .1 | 8.4 | .0 | 4.1 | .0 | .0 | 29.1 | .0 | .0 | .0 | .0 | .0 | 5.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 24 | .0 | 24.8 | 3.8 | 3.8 | 8.4 | .0 | 4.5 | 4.6 | 3.8 | .0 | 8.7 | .0 | 4.1 | .0 | .0 | 28.4 | .0 | .0 | .0 | .0 | .0 | 5.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 25 | .0 | 22.7 | 4.0 | 2.9 | 7.8 | 1.5 | 5.3 | 4.1 | 3.4 | .4 | 9.4 | .5 | 3.4 | .0 | .3 | 28.6 | .1 | .0 | .0 | .0 | .2 | 5.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 26 | .0 | 20.7 | 3.9 | 2.3 | 7.0 | 2.2 | 5.9 | 3.5 | 2.9 | .8 | 9.6 | 1.0 | 3.1 | .0 | .6 | 29.8 | .3 | .0 | .1 | .0 | .6 | 5.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 27 | .0 | 18.4 | 3.8 | 2.0 | 6.0 | 2.4 | 6.0 | 3.0 | 2.5 | 1.0 | 10.5 | 1.3 | 2.6 | .0 | 1.3 | 30.4 | .6 | .0 | .3 | .0 | 1.3 | 6.2 | .3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 28 | .0 | 16.0 | 3.6 | 1.9 | 5.0 | 2.4 | 6.0 | 2.4 | 2.2 | 1.3 | 10.6 | 1.7 | 2.5 | .0 | 1.9 | 31.7 | 1.0 | .0 | .5 | .0 | 1.9 | 6.4 | .8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 29 | .0 | 13.4 | 3.5 | 1.6 | 3.8 | 2.8 | 6.3 | 2.1 | 2.0 | 1.4 | 10.3 | 1.7 | 2.5 | .0 | 2.1 | 32.8 | 1.5 | .0 | .7 | .0 | 2.8 | 6.9 | 1.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 30 | .0 | 10.6 | 3.6 | 1.3 | 3.4 | 2.7 | 6.1 | 2.0 | 1.6 | 1.4 | 10.2 | 1.5 | 2.1 | .0 | 2.2 | 33.8 | 2.1 | .0 | .9 | .0 | 4.0 | 7.8 | 2.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 31 | .0 | 8.4 | 3.2 | 1.1 | 2.8 | 2.5 | 5.5 | 1.7 | 1.3 | 1.6 | 10.6 | 1.6 | 1.8 | .0 | 2.5 | 34.9 | 2.2 | .0 | 1.0 | .0 | 5.3 | 8.4 | 3.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 32 | .0 | 6.5 | 2.6 | .9 | 2.3 | 2.3 | 5.4 | 1.9 | 1.1 | 1.6 | 10.2 | 1.5 | 1.6 | .0 | 2.7 | 36.2 | 2.5 | .0 | 1.0 | .0 | 6.8 | 9.4 | 3.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 33 | .0 | 4.5 | 2.3 | .8 | 1.8 | 2.2 | 5.6 | 1.5 | 1.2 | 1.7 | 9.6 | 1.5 | 1.2 | .0 | 2.7 | 38.6 | 2.5 | .0 | 1.1 | .0 | 7.2 | 10.0 | 3.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 34 | .0 | 3.3 | 2.1 | .9 | 1.5 | 2.2 | 5.3 | 1.4 | 1.0 | 1.7 | 9.2 | 1.1 | 1.1 | .0 | 3.2 | 40.8 | 2.5 | .0 | 1.1 | .0 | 7.4 | 10.7 | 3.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 35 | .0 | 2.4 | 1.7 | .8 | 1.4 | 1.6 | 4.9 | 1.5 | 1.1 | 1.7 | 9.3 | 1.3 | 1.2 | .0 | 3.5 | 42.1 | 2.5 | .0 | .9 | .0 | 7.0 | 11.3 | 3.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 36 | .0 | 2.3 | 1.8 | 1.1 | 1.4 | 1.2 | 4.4 | 1.5 | 1.3 | 1.6 | 9.4 | 1.3 | 1.3 | .0 | 3.4 | 43.5 | 2.2 | .0 | .9 | .0 | 6.8 | 11.0 | 3.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 37 | .0 | 2.5 | 1.6 | 1.0 | 2.1 | .9 | 4.1 | 1.9 | 1.5 | 1.3 | 10.2 | 1.1 | 1.3 | .0 | 2.8 | 43.4 | 2.0 | .0 | .9 | .0 | 6.9 | 11.3 | 3.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 38 | .0 | 3.2 | 1.5 | 1.1 | 2.8 | .6 | 4.1 | 2.5 | 2.0 | .8 | 9.8 | .6 | 1.7 | .0 | 2.3 | 43.2 | 1.6 | .0 | .8 | .0 | 7.0 | 11.0 | 3.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 39 | .0 | 4.4 | 1.6 | 1.4 | 3.3 | .4 | 4.2 | 3.2 | 2.2 | .8 | 10.0 | .3 | 1.8 | .0 | 1.7 | 42.7 | 1.7 | .0 | .6 | .0 | 6.3 | 10.6 | 2.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 40 | .0 | 5.4 | 1.8 | 1.8 | 4.0 | .3 | 4.1 | 3.7 | 3.0 | .7 | 10.2 | .3 | 2.2 | .0 | 1.2 | 42.3 | 1.2 | .0 | .5 | .0 | 5.3 | 10.0 | 2.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 41 | .0 | 6.6 | 2.2 | 2.3 | 4.9 | .4 | 4.0 | 3.8 | 3.3 | .5 | 9.9 | .2 | 2.8 | .0 | 1.0 | 42.6 | 1.1 | .0 | .4 | .0 | 3.4 | 9.1 | 1.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 42 | .0 | 8.0 | 2.5 | 2.6 | 5.5 | .2 | 4.0 | 4.4 | 3.6 | .4 | 10.1 | .1 | 3.2 | .0 | .8 | 41.3 | .6 | .0 | .2 | .0 | 2.9 | 8.4 | 1.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 43 | .0 | 9.7 | 2.9 | 2.6 | 6.7 | .1 | 4.3 | 4.7 | 3.9 | .3 | 9.7 | .1 | 3.7 | .0 | .9 | 39.6 | .4 | .0 | .1 | .0 | 1.7 | 8.1 | .6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 44 | .0 | 11.6 | 3.2 | 2.7 | 7.6 | .1 | 4.6 | 4.9 | 4.2 | .2 | 9.9 | .1 | 3.9 | .0 | .6 | 37.9 | .1 | .0 | .1 | .0 | .9 | 7.4 | .3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 45 | .0 | 13.4 | 3.7 | 3.0 | 8.1 | .1 | 4.9 | 5.4 | 4.2 | .0 | 9.6 | .1 | 4.3 | .0 | .4 | 35.5 | .1 | .0 | .0 | .0 | .4 | 6.9 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 46 | .0 | 15.2 | 4.2 | 3.0 | 8.6 | .0 | 4.8 | 5.5 | 4.4 | .1 | 9.1 | .0 | 4.6 | .0 | .1 | 33.9 | .0 | .0 | .0 | .0 | .1 | 6.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 47 | .0 | 16.9 | 4.5 | 3.1 | 9.0 | .0 | 4.8 | 6.0 | 4.3 | .0 | 8.9 | .0 | 4.4 | .0 | .0 | 31.9 | .0 | .0 | .0 | .0 | .0 | 6.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 48 | .0 | 18.1 | 4.8 | 3.2 | 9.0 | .0 | 5.3 | 5.5 | 4.1 | .0 | 8.6 | .1 | 4.5 | .0 | .0 | 31.2 | .0 | .0 | .0 | .0 | .0 | 5.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 49 | .0 | 17.2 | 4.9 | 2.6 | 8.1 | 1.3 | 5.8 | 4.5 | 4.2 | .7 | 9.3 | .3 | 4.2 | .0 | .4 | 30.5 | .0 | .0 | .0 | .0 | .1 | 5.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 50 | .0 | 15.6 | 4.9 | 2.3 | 7.5 | 1.7 | 5.9 | 3.9 | 3.6 | 1.1 | 9.8 | .9 | 4.0 | .0 | .9 | 31.3 | .1 | .0 | .1 | .0 | .4 | 5.6 | .2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 51 | .0 | 14.2 | 5.1 | 1.9 | 6.4 | 2.0 | 6.3 | 3.2 | 3.3 | 1.5 | 9.5 | 1.1 | 3.8 | .0 | 1.6 | 32.1 | .4 | .0 | .2 | .0 | 1.0 | 6.0 | .4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 52 | .0 | 12.7 | 4.9 | 1.7 | 5.1 | 2.1 | 6.0 | 2.6 | 3.3 | 1.7 | 9.8 | 1.3 | 3.3 | .0 | 2.0 | 33.3 | 1.0 | .0 | .3 | .0 | 2.0 | 6.2 | .7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 53 | .0 | 11.2 | 4.6 | 1.2 | 4.4 | 2.1 | 6.3 | 2.1 | 2.8 | 1.8 | 9.8 | 1.2 | 3.2 | .0 | 2.2 | 33.3 | 1.2 | .0 | .5 | .0 | 2.9 | 7.4 | 1.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 54 | .0 | 9.3 | 4.3 | .9 | 3.9 | 2.4 | 6.5 | 1.7 | 2.5 | 1.9 | 9.3 | 1.3 | 2.9 | .0 | 2.8 | 34.5 | 1.7 | .0 | .6 | .0 | 4.3 | 7.8 | 2.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 55 | .0 | 8.0 | 3.8 | .8 | 3.2 | 2.3 | 6.1 | 1.3 | 2.2 | 2.0 | 10.0 | 1.3 | 2.1 | .0 | 2.3 | 35.2 | 1.7 | .0 | .7 | .0 | 5.4 | 8.8 | 3.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 56 | .0 | 6.2 | 3.4 | .7 | 2.7 | 2.3 | 6.0 | 1.2 | 1.6 | 2.1 | 9.3 | 1.5 | 1.9 | .0 | 2.6 | 36.8 | 2.3 | .0 | .7 | .0 | 6.2 | 9.4 | 3.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 57 | .0 | 4.8 | 2.9 | .5 | 2.2 | 2.1 | 5.6 | 1.1 | 1.4 | 2.2 | 9.3 | 1.3 | 1.4 | .0 | 2.8 | 39.0 | 2.4 | .0 | .8 | .0 | 6.6 | 10.1 | 3.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 58 | .0 | 3.5 | 2.6 | .8 | 1.7 | 1.8 | 5.2 | 1.1 | 1.5 | 2.0 | 9.5 | 1.2 | 1.3 | .0 | 3.2 | 40.4 | 2.2 | .0 | .9 | .0 | 6.9 | 10.6 | 3.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 59 | .0 | 2.5 | 2.5 | .7 | 1.7 | 1.6 | 4.5 | 1.1 | 1.3 | 1.9 | 10.2 | 1.4 | 1.1 | .0 | 3.0 | 41.7 | 2.4 | .0 | .8 | .0 | 7.4 | 11.0 | 3.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 60 | .0 | 2.1 | 2.4 | .6 | 1.8 | 1.1 | 4.6 | 1.3 | 1.6 | 1.7 | 10.2 | 1.2 | 1.3 | .0 | 2.9 | 41.8 | 2.5 | .0 | .8 | .0 | 7.2 | 11.7 | 3.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 61 | .0 | 2.5 | 2.1 | .8 | 2.0 | .7 | 4.3 | 1.5 | 1.9 | 1.6 | 10.3 | 1.0 | 1.7 | .0 | 2.4 | 42.8 | 2.1 | .0 | .7 | .0 | 6.8 | 11.8 | 3.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 62 | .0 | 3.4 | 1.9 | 1.1 | 2.6 | .6 | 4.1 | 2.2 | 2.3 | 1.3 | 10.5 | .6 | 2.2 | .0 | 2.1 | 42.2 | 1.9 | .0 | .5 | .0 | 6.0 | 11.6 | 2.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 63 | .0 | 4.8 | 1.5 | 1.7 | 3.8 | .4 | 4.5 | 2.7 | 2.7 | .8 | 10.4 | .4 | 2.6 | .0 | 1.6 | 41.4 | 1.8 | .0 | .4 | .0 | 5.4 | 11.4 | 2.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 64 | .0 | 5.9 | 1.6 | 1.9 | 4.1 | .4 | 4.4 | 3.0 | 3.2 | .7 | 10.2 | .1 | 3.1 | .0 | 1.5 | 40.7 | 1.5 | .0 | .3 | .0 | 4.4 | 10.7 | 2.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 65 | .0 | 7.9 | 1.7 | 2.3 | 4.7 | .4 | 4.4 | 3.4 | 3.7 | .6 | 10.0 | .1 | 3.8 | .0 | 1.2 | 38.9 | 1.3 | .0 | .2 | .0 | 3.7 | 10.2 | 1.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 66 | .0 | 9.7 | 2.0 | 2.5 | 5.2 | .3 | 4.5 | 3.9 | 4.1 | .5 | 10.3 | .1 | 4.3 | .0 | 1.1 | 37.5 | 1.1 | .0 | .2 | .0 | 2.5 | 9.3 | .8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 67 | .0 | 11.4 | 2.4 | 2.7 | 6.0 | .2 | 4.8 | 4.2 | 4.8 | .4 | 9.8 | .1 | 4.8 | .0 | .9 | 35.6 | .6 | .0 | .3 | .0 | 1.6 | 9.0 | .7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 68 | .0 | 13.3 | 2.8 | 2.5 | 7.1 | .1 | 4.9 | 4.4 | 5.1 | .2 | 9.5 | .1 | 4.8 | .0 | .7 | 34.1 | .4 | .0 | .1 | .0 | 1.0 | 8.5 | .4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 69 | .0 | 15.2 | 3.3 | 2.8 | 8.0 | .1 | 4.8 | 5.0 | 5.6 | .3 | 9.3 | .1 | 4.6 | .0 | .5 | 31.9 | .3 | .0 | .0 | .0 | .3 | 7.9 | .2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 70 | .0 | 17.3 | 3.7 | 2.7 | 8.3 | .0 | 4.9 | 5.0 | 5.6 | .1 | 8.8 | .1 | 5.0 | .0 | .2 | 31.0 | .1 | .0 | .0 | .0 | .1 | 7.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 71 | .0 | 18.8 | 4.4 | 2.7 | 8.8 | .1 | 4.8 | 4.3 | 5.6 | .0 | 8.7 | .0 | 5.0 | .0 | .1 | 29.6 | .1 | .0 | .0 | .0 | .0 | 7.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 72 | .0 | 20.2 | 4.9 | 2.5 | 8.2 | .1 | 5.2 | 4.1 | 5.3 | .0 | 8.6 | .1 | 5.1 | .0 | .1 | 29.0 | .0 | .0 | .0 | .0 | .1 | 6.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |

**TABLE E.5:** Percentage frequency of occurrence of different atmospheric conditions ij for a start condition of 61 (72 hour period, 5 years of data for St. John Airport, elevated release, downwind distance 5 km).

| | 61 | 51 | 62 | 52 | 41 | 63 | 53 | 42 | 31 | 64 | 54 | 43 | 32 | 21 | 65 | 55 | 44 | 33 | 22 | 11 | 45 | 34 | 23 | 12 | 35 | 24 | 13 | 25 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 68.2 | .0 | 11.3 | 2.0 | 2.4 | 2.5 | 2.3 | 1.5 | 4.0 | .0 | .0 | 1.0 | .0 | 1.6 | .0 | .0 | .9 | .2 | .3 | .0 | .0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 2 | 56.6 | .0 | 10.4 | 2.4 | 3.0 | 2.7 | 2.5 | 3.0 | 5.0 | .0 | .9 | 2.1 | 1.6 | 3.1 | .0 | .0 | 2.6 | .7 | .9 | .3 | .0 | .5 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 3 | 47.6 | .0 | 9.7 | 2.2 | 4.1 | 2.4 | 2.1 | 4.1 | 6.0 | .0 | 1.2 | 3.4 | 2.2 | 3.8 | .0 | .0 | 4.5 | 1.9 | 1.9 | .0 | .1 | 1.4 | .5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 4 | 39.1 | .0 | 8.3 | 1.6 | 4.0 | 2.5 | 2.3 | 4.4 | 6.0 | .0 | 1.5 | 4.0 | 2.4 | 4.3 | .0 | .0 | 7.1 | 3.1 | 2.7 | 1.2 | .3 | 2.7 | 1.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 5 | 32.1 | .0 | 7.2 | 1.4 | 4.1 | 2.0 | 2.0 | 4.5 | 6.0 | .0 | 1.1 | 5.9 | 2.5 | 4.3 | .0 | .0 | 10.0 | 3.5 | 3.4 | 1.6 | .6 | 4.6 | 3.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 6 | 25.2 | .0 | 5.8 | 1.1 | 3.5 | 1.5 | 2.1 | 5.2 | 5.7 | .0 | 1.4 | 6.4 | 2.7 | 4.1 | .0 | .0 | 13.6 | 3.6 | 3.9 | 2.0 | 1.3 | 6.3 | 4.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 7 | 19.3 | .0 | 4.9 | .8 | 3.4 | 1.3 | 1.8 | 5.2 | 5.3 | .0 | 1.2 | 6.5 | 2.7 | 4.1 | .0 | .0 | 17.8 | 4.0 | 4.2 | 1.9 | 2.0 | 8.2 | 5.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 8 | 14.3 | .0 | 4.1 | .9 | 2.9 | 1.1 | 1.5 | 5.3 | 5.1 | .0 | 1.2 | 6.7 | 2.9 | 3.8 | .0 | .0 | 21.6 | 4.2 | 4.1 | 1.8 | 3.3 | 9.1 | 6.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 9 | 10.7 | .0 | 3.0 | .7 | 2.3 | 1.1 | 1.6 | 4.9 | 4.6 | .0 | .9 | 7.2 | 3.0 | 3.6 | .0 | .0 | 26.0 | 4.1 | 4.4 | 1.7 | 4.1 | 10.3 | 6.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 10 | 7.6 | .0 | 2.7 | .7 | 1.8 | 1.1 | 1.2 | 4.5 | 3.7 | .0 | .8 | 8.3 | 2.9 | 3.3 | .0 | .0 | 29.1 | 4.3 | 4.0 | 1.6 | 5.3 | 11.3 | 5.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 11 | 5.3 | .0 | 2.3 | .8 | 1.5 | 1.1 | 1.3 | 4.2 | 2.9 | .0 | .7 | 8.5 | 2.6 | 3.2 | .0 | .0 | 33.5 | 4.6 | 3.9 | 1.4 | 5.7 | 11.0 | 5.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 12 | 4.3 | .0 | 2.4 | 1.2 | 1.3 | 1.4 | 1.5 | 4.0 | 1.8 | .0 | 1.0 | 8.8 | 2.3 | 2.7 | .0 | .0 | 35.9 | 4.3 | 3.6 | 1.3 | 6.3 | 10.4 | 5.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 13 | 4.3 | .0 | 2.7 | 1.1 | 1.1 | 1.5 | 1.9 | 4.0 | 1.3 | .0 | 1.1 | 8.8 | 1.8 | 2.0 | .0 | .0 | 38.0 | 3.3 | 3.3 | 1.3 | 6.7 | 9.5 | 5.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 14 | 4.9 | .0 | 3.0 | 1.6 | 1.2 | 2.0 | 2.9 | 3.7 | 1.0 | .0 | 1.5 | 8.4 | 1.2 | 1.3 | .0 | .0 | 40.4 | 2.8 | 2.4 | 1.3 | 6.7 | 8.7 | 4.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 15 | 6.5 | .0 | 3.8 | 2.2 | 1.4 | 2.1 | 3.6 | 3.6 | .8 | .0 | 1.8 | 8.4 | .9 | .7 | .0 | .0 | 40.2 | 2.7 | 2.3 | 1.1 | 7.0 | 7.4 | 3.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 16 | 8.5 | .0 | 4.4 | 2.4 | 1.6 | 2.7 | 4.2 | 3.7 | .7 | .0 | 2.3 | 8.5 | .8 | .3 | .0 | .0 | 39.6 | 2.1 | 1.5 | .7 | 7.0 | 5.7 | 3.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 17 | 10.5 | .0 | 5.5 | 2.9 | 1.8 | 3.1 | 4.6 | 3.7 | .5 | .0 | 2.7 | 8.9 | .7 | .2 | .0 | .0 | 38.2 | 2.0 | 1.1 | .4 | 6.3 | 4.6 | 2.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 18 | 12.9 | .0 | 6.5 | 3.1 | 1.8 | 3.3 | 4.9 | 4.2 | .4 | .0 | 2.9 | 9.2 | .4 | .1 | .0 | .0 | 37.2 | 1.5 | .8 | .1 | 6.2 | 3.2 | 1.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 19 | 15.0 | .0 | 7.0 | 3.3 | 2.0 | 4.0 | 5.3 | 3.8 | .2 | .0 | 3.4 | 9.3 | .5 | .1 | .0 | .0 | 35.0 | 1.1 | .4 | .0 | 5.9 | 2.0 | .7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 20 | 17.2 | .0 | 8.2 | 3.6 | 2.2 | 4.0 | 5.1 | 4.2 | .1 | .0 | 3.9 | 8.9 | .4 | .0 | .0 | .0 | 34.1 | .9 | .2 | .0 | 5.8 | .8 | .3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 21 | 19.5 | .0 | 8.6 | 3.5 | 2.6 | 4.1 | 5.6 | 4.2 | .1 | .0 | 4.1 | 8.7 | .2 | .0 | .0 | .0 | 32.5 | .3 | .1 | .0 | 5.5 | .3 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 22 | 22.1 | .0 | 8.7 | 3.4 | 3.0 | 4.8 | 5.6 | 4.1 | .0 | .0 | 4.1 | 8.6 | .1 | .0 | .0 | .0 | 30.1 | .1 | .1 | .0 | 5.2 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 23 | 23.5 | .0 | 9.0 | 3.6 | 3.3 | 4.2 | 5.4 | 4.1 | .0 | .0 | 4.1 | 8.4 | .1 | .0 | .0 | .0 | 29.1 | .0 | .0 | .0 | 5.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 24 | 24.8 | .0 | 8.4 | 3.8 | 3.8 | 3.8 | 4.6 | 4.5 | .0 | .0 | 4.1 | 8.7 | .0 | .0 | .0 | .0 | 28.4 | .0 | .0 | .0 | 5.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 25 | 22.7 | .0 | 7.8 | 2.9 | 4.0 | 3.4 | 4.1 | 5.3 | 1.5 | .0 | 3.4 | 9.4 | .4 | .5 | .0 | .0 | 28.6 | .3 | .1 | .0 | 5.4 | .2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 26 | 20.7 | .0 | 7.0 | 2.3 | 3.9 | 2.9 | 3.5 | 5.9 | 2.2 | .0 | 3.1 | 9.6 | .8 | 1.0 | .0 | .0 | 29.0 | .6 | .3 | .1 | 5.7 | .6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 27 | 18.4 | .0 | 6.0 | 2.0 | 3.8 | 2.5 | 3.0 | 6.0 | 2.4 | .0 | 2.6 | 10.5 | 1.0 | 1.3 | .0 | .0 | 30.4 | 1.3 | .6 | .3 | 6.2 | 1.3 | .3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 28 | 16.0 | .0 | 5.0 | 1.9 | 3.6 | 2.2 | 2.4 | 6.0 | 2.4 | .0 | 2.5 | 10.6 | 1.3 | 1.7 | .0 | .0 | 31.7 | 1.9 | 1.0 | .5 | 6.4 | 1.9 | .8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 29 | 13.4 | .0 | 3.8 | 1.6 | 3.5 | 2.0 | 2.1 | 6.3 | 2.8 | .0 | 2.5 | 10.3 | 1.4 | 1.7 | .0 | .0 | 32.0 | 2.1 | 1.5 | .7 | 6.9 | 2.8 | 1.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 30 | 10.6 | .0 | 3.4 | 1.3 | 3.6 | 1.6 | 2.0 | 6.1 | 2.7 | .0 | 2.1 | 10.2 | 1.4 | 1.5 | .0 | .0 | 33.0 | 2.2 | 2.1 | .9 | 7.8 | 4.0 | 2.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 31 | 8.4 | .0 | 2.8 | 1.1 | 3.2 | 1.3 | 1.7 | 5.5 | 2.5 | .0 | 1.8 | 10.6 | 1.6 | 1.6 | .0 | .0 | 34.9 | 2.5 | 2.2 | 1.0 | 8.4 | 5.3 | 3.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 32 | 6.5 | .0 | 2.3 | .9 | 2.6 | 1.1 | 1.9 | 5.4 | 2.3 | .0 | 1.6 | 10.2 | 1.6 | 1.5 | .0 | .0 | 36.2 | 2.7 | 2.5 | 1.0 | 9.4 | 6.0 | 3.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 33 | 4.5 | .0 | 1.8 | .8 | 2.3 | 1.2 | 1.5 | 5.6 | 2.2 | .0 | 1.2 | 9.6 | 1.7 | 1.5 | .0 | .0 | 38.6 | 2.7 | 2.5 | 1.1 | 10.0 | 7.2 | 3.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 34 | 3.3 | .0 | 1.5 | .9 | 2.1 | 1.0 | 1.4 | 5.3 | 2.2 | .0 | 1.1 | 9.2 | 1.7 | 1.1 | .0 | .0 | 40.0 | 3.2 | 2.5 | 1.1 | 10.7 | 7.4 | 3.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 35 | 2.4 | .0 | 1.4 | .8 | 1.7 | 1.1 | 1.5 | 4.9 | 1.6 | .0 | 1.2 | 9.3 | 1.7 | 1.3 | .0 | .0 | 42.1 | 3.5 | 2.5 | .9 | 11.3 | 7.0 | 3.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 36 | 2.3 | .0 | 1.4 | 1.1 | 1.8 | 1.3 | 1.5 | 4.4 | 1.2 | .0 | 1.3 | 9.4 | 1.6 | 1.3 | .0 | .0 | 43.5 | 3.4 | 2.2 | .9 | 11.0 | 6.8 | 3.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 37 | 2.5 | .0 | 2.1 | 1.0 | 1.6 | 1.5 | 1.9 | 4.1 | .9 | .0 | 1.3 | 10.2 | 1.3 | 1.1 | .0 | .0 | 43.4 | 2.0 | 2.0 | .9 | 11.3 | 6.9 | 3.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 38 | 3.2 | .0 | 2.8 | 1.1 | 1.5 | 2.0 | 2.5 | 4.1 | .6 | .0 | 1.7 | 9.8 | .8 | .6 | .0 | .0 | 43.2 | 2.3 | 1.6 | .8 | 11.0 | 7.0 | 3.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 39 | 4.4 | .0 | 3.3 | 1.4 | 1.6 | 2.2 | 3.2 | 4.2 | .4 | .0 | 1.8 | 10.0 | .8 | .3 | .0 | .0 | 42.7 | 1.7 | 1.7 | .6 | 10.6 | 6.3 | 2.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 40 | 5.4 | .0 | 4.0 | 1.8 | 1.8 | 3.0 | 3.7 | 4.1 | .3 | .0 | 2.2 | 10.2 | .7 | .3 | .0 | .0 | 42.3 | 1.2 | 1.2 | .5 | 10.0 | 5.3 | 2.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 41 | 6.6 | .0 | 4.9 | 2.3 | 2.2 | 3.3 | 3.8 | 4.0 | .4 | .0 | 2.8 | 9.9 | .5 | .2 | .0 | .0 | 42.6 | 1.0 | 1.1 | .4 | 9.1 | 3.4 | 1.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 42 | 8.0 | .0 | 5.5 | 2.6 | 2.5 | 3.6 | 4.4 | 4.8 | .2 | .0 | 3.2 | 10.1 | .4 | .1 | .0 | .0 | 41.3 | .8 | .6 | .2 | 8.4 | 2.9 | 1.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 43 | 9.7 | .0 | 6.7 | 2.6 | 2.9 | 3.9 | 4.7 | 4.3 | .1 | .0 | 3.7 | 9.7 | .3 | .1 | .0 | .0 | 39.6 | .8 | .4 | .1 | 8.1 | 1.7 | .6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 44 | 11.6 | .0 | 7.6 | 2.7 | 3.2 | 4.2 | 4.9 | 4.6 | .1 | .0 | 3.9 | 9.9 | .2 | .1 | .0 | .0 | 37.9 | .6 | .1 | .1 | 7.4 | .9 | .3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 45 | 13.4 | .0 | 8.1 | 3.0 | 3.7 | 4.2 | 5.4 | 4.9 | .1 | .0 | 4.3 | 9.6 | .0 | .1 | .0 | .0 | 35.5 | .4 | .1 | .0 | 6.9 | .4 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 46 | 15.2 | .0 | 8.6 | 3.0 | 4.2 | 4.4 | 5.5 | 4.8 | .0 | .0 | 4.6 | 9.1 | .1 | .0 | .0 | .0 | 33.9 | .1 | .0 | .0 | 6.4 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 47 | 16.9 | .0 | 9.0 | 3.1 | 4.5 | 4.3 | 6.0 | 4.8 | .0 | .0 | 4.4 | 8.9 | .0 | .0 | .0 | .0 | 31.9 | .0 | .0 | .0 | 6.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 48 | 18.1 | .0 | 9.0 | 3.2 | 4.8 | 4.1 | 5.5 | 5.3 | .0 | .0 | 4.5 | 8.6 | .0 | .1 | .0 | .0 | 31.2 | .0 | .0 | .0 | 5.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 49 | 17.2 | .0 | 8.1 | 2.6 | 4.9 | 4.2 | 4.5 | 5.8 | 1.3 | .0 | 4.2 | 9.3 | .7 | .3 | .0 | .0 | 30.5 | .4 | .0 | .0 | 5.8 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 50 | 15.6 | .0 | 7.5 | 2.3 | 4.9 | 3.6 | 3.9 | 5.9 | 1.7 | .0 | 4.0 | 9.8 | 1.1 | .9 | .0 | .0 | 31.3 | .9 | .1 | .1 | 5.6 | .4 | .2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 51 | 14.2 | .0 | 6.4 | 1.9 | 5.1 | 3.3 | 3.2 | 6.3 | 2.0 | .0 | 3.8 | 9.5 | 1.5 | 1.1 | .0 | .0 | 32.1 | 1.6 | .4 | .2 | 6.0 | 1.0 | .4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 52 | 12.7 | .0 | 5.1 | 1.7 | 4.9 | 3.3 | 2.6 | 6.0 | 2.1 | .0 | 3.3 | 9.8 | 1.7 | 1.3 | .0 | .0 | 33.3 | 2.0 | 1.0 | .3 | 6.2 | 2.0 | .7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 53 | 11.2 | .0 | 4.4 | 1.2 | 4.6 | 2.8 | 2.1 | 6.3 | 2.1 | .0 | 3.2 | 9.8 | 1.8 | 1.2 | .0 | .0 | 33.3 | 2.2 | 1.2 | .5 | 7.4 | 2.9 | 1.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 54 | 9.3 | .0 | 3.9 | .9 | 4.3 | 2.5 | 1.7 | 6.5 | 2.4 | .0 | 2.9 | 9.3 | 1.9 | 1.3 | .0 | .0 | 34.5 | 2.0 | 1.7 | .6 | 7.0 | 4.3 | 2.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 55 | 8.0 | .0 | 3.2 | .8 | 3.8 | 2.2 | 1.3 | 6.1 | 2.3 | .0 | 2.1 | 10.0 | 2.0 | 1.3 | .0 | .0 | 35.2 | 2.3 | 1.7 | .7 | 8.8 | 5.4 | 3.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 56 | 6.2 | .0 | 2.7 | .7 | 3.4 | 1.6 | 1.2 | 6.0 | 2.3 | .0 | 1.9 | 9.3 | 2.1 | 1.5 | .0 | .0 | 36.8 | 2.6 | 2.3 | .7 | 9.4 | 6.2 | 3.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 57 | 4.8 | .0 | 2.2 | .5 | 2.9 | 1.4 | 1.1 | 5.6 | 2.1 | .0 | 1.4 | 9.3 | 2.2 | 1.3 | .0 | .0 | 39.0 | 2.8 | 2.4 | .8 | 10.1 | 6.6 | 3.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 58 | 3.5 | .0 | 1.7 | .8 | 2.6 | 1.5 | 1.1 | 5.2 | 1.8 | .0 | 1.3 | 9.5 | 2.0 | 1.2 | .0 | .0 | 40.4 | 3.2 | 2.2 | .9 | 10.6 | 6.9 | 3.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 59 | 2.5 | .0 | 1.7 | .7 | 2.5 | 1.3 | 1.1 | 4.5 | 1.6 | .0 | 1.1 | 10.2 | 1.9 | 1.4 | .0 | .0 | 41.7 | 3.0 | 2.4 | .8 | 11.0 | 7.4 | 3.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 60 | 2.1 | .0 | 1.8 | .6 | 2.4 | 1.6 | 1.3 | 4.6 | 1.1 | .0 | 1.3 | 10.2 | 1.7 | 1.2 | .0 | .0 | 41.8 | 2.9 | 2.5 | .8 | 11.7 | 7.2 | 3.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 61 | 2.5 | .0 | 2.0 | .8 | 2.1 | 1.9 | 1.5 | 4.3 | .7 | .0 | 1.7 | 10.3 | 1.6 | 1.0 | .0 | .0 | 42.0 | 2.4 | 2.1 | .7 | 11.8 | 6.8 | 3.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 62 | 3.4 | .0 | 2.6 | 1.1 | 1.9 | 2.3 | 2.2 | 4.1 | .6 | .0 | 2.2 | 10.5 | 1.3 | .6 | .0 | .0 | 42.2 | 2.1 | 1.9 | .5 | 11.6 | 6.0 | 2.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 63 | 4.8 | .0 | 3.0 | 1.7 | 1.5 | 2.7 | 2.7 | 4.5 | .4 | .0 | 2.6 | 10.4 | .8 | .4 | .0 | .0 | 41.4 | 1.6 | 1.8 | .4 | 11.4 | 5.4 | 2.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 64 | 5.9 | .0 | 4.1 | 1.9 | 1.6 | 3.2 | 3.0 | 4.4 | .4 | .0 | 3.1 | 10.2 | .7 | .1 | .0 | .0 | 40.7 | 1.5 | 1.5 | .3 | 10.7 | 4.4 | 2.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 65 | 7.9 | .0 | 4.7 | 2.3 | 1.7 | 3.7 | 3.4 | 4.4 | .4 | .0 | 3.8 | 10.0 | .6 | .1 | .0 | .0 | 38.9 | 1.2 | 1.3 | .2 | 10.2 | 3.7 | 1.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 66 | 9.7 | .0 | 5.2 | 2.5 | 2.0 | 4.1 | 3.9 | 4.5 | .3 | .0 | 4.3 | 10.3 | .5 | .1 | .0 | .0 | 37.5 | 1.1 | 1.1 | .2 | 9.3 | 2.5 | .8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 67 | 11.4 | .0 | 6.0 | 2.7 | 2.4 | 4.8 | 4.2 | 4.8 | .2 | .0 | 4.8 | 9.8 | .4 | .1 | .0 | .0 | 35.6 | .9 | .6 | .3 | 9.0 | 1.6 | .7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 68 | 13.3 | .0 | 7.1 | 2.5 | 2.8 | 5.1 | 4.4 | 4.9 | .1 | .0 | 4.8 | 9.5 | .2 | .1 | .0 | .0 | 34.1 | .7 | .4 | .1 | 8.5 | 1.0 | .4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 69 | 15.2 | .0 | 8.0 | 2.8 | 3.3 | 5.6 | 5.0 | 4.8 | .1 | .0 | 4.6 | 9.3 | .3 | .1 | .0 | .0 | 31.9 | .5 | .3 | .0 | 7.9 | .3 | .2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 70 | 17.3 | .0 | 8.3 | 2.7 | 3.7 | 5.6 | 5.0 | 4.9 | .0 | .0 | 5.0 | 8.8 | .1 | .1 | .0 | .0 | 31.0 | .2 | .1 | .0 | 7.0 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 71 | 18.8 | .0 | 8.8 | 2.7 | 4.4 | 5.6 | 4.3 | 4.8 | .1 | .0 | 5.0 | 8.7 | .0 | .0 | .0 | .0 | 29.6 | .1 | .1 | .0 | 7.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 72 | 20.2 | .0 | 8.2 | 2.5 | 4.9 | 5.3 | 4.1 | 5.2 | .1 | .0 | 5.1 | 8.6 | .0 | .1 | .0 | .0 | 29.8 | .1 | .0 | .0 | 6.7 | .1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |

TABLE E.6: The Time Integrated Concentrations That Should Not Be Exceeded More Than 10% of the Time, $\chi_{10-t}$, for Different Release Durations, t. (5 year data, St. John Airport, ground level release)

| Duration of Release, t (hr) | $\chi_{10-t}$ ($Ci \cdot s \cdot m^{-3}$) |
|---|---|
| 720 | $0.8993 \times 10^{-1}$ |
| 240 | $0.3132 \times 10^{-1}$ |
| 72 | $0.1106 \times 10^{-1}$ |
| 24 | $0.4897 \times 10^{-2}$ |
| 8 | $0.2049 \times 10^{-2}$ |
| 4 | $0.1144 \times 10^{-2}$ |
| 1 | $\sim 0.2558 \times 10^{-3}$ |

TABLE E.7: "Percentage Criteria" for ground level release 5 yr data St. John Airport

| Duration release t (hr) | $\chi_{10-t}$ ($Ci \cdot s \cdot m^{-3}$) | $P_{10-t}$ (%) |
|---|---|---|
| 720 | $0.8993 \times 10^{-1}$ | 23 |
| 240 | $0.3132 \times 10^{-1}$ | 24 |
| 72 | $0.1106 \times 10^{-1}$ | 25 |
| 24 | $0.4897 \times 10^{-2}$ | 29 |
| 8 | $0.2049 \times 10^{-2}$ | 47 |
| 4 | $0.1144 \times 10^{-2}$ | 57 |
| 1 | $\sim 0.2558 \times 10^{-3}$ | ~ 79 |

TABLE E.8: Number of Hourly Occurrences of Each Wind Direction Which Is Not Exceeded in More Than 10% of the ~42,000 720-Hour Scenarios (5 year data, St. John Airport)

| Direction Class | Number of Hourly Occurrences That Will Not Be Exceeded More than 10% of the Time | Percentage Occurrences That Will Not Be Exceeded More Than 10% of the Time |
|---|---|---|
| 1 | 112.5 | 15.6 |
| 2 | 96 | 13.3 |
| 3 | ~ 42 | 5.8 |
| 4 | < 30 | 4.2 |
| 5 | 48 | 6.6 |
| 6 | 45 | 6.3 |
| 7 | < 30 | 4.2 |
| 8 | 45 | 6.3 |
| 9 | 132 | 18.3 |
| 10 | 183 | 25.4 |
| 11 | 108 | 15.0 |
| 12 | 51 | 7.1 |
| 13 | 99 | 13.7 |
| 14 | 90 | 12.5 |
| 15 | 114 | 15.8 |
| 16 | 81 | 11.3 |

TABLE E.9: Number of Hourly Occurrences of Wind in the Same Direction That Will Not be Exceeded For Any Direction in More Than 10% of the ~42,000 Scenarios for Different Release Durations (5 year data, St. John Airport)

| Duration of Release (hrs) | Number of Hourly Occurrences | Percentage of Hourly Occurrences |
|---|---|---|
| 1 | 1 | 100 |
| 12 | 6.1 | 51 |
| 48 | 17.8 | 37 |
| 96 | 31 | 32 |
| 240 | 77.5 | 32 |
| 720 | 183 | 25 |

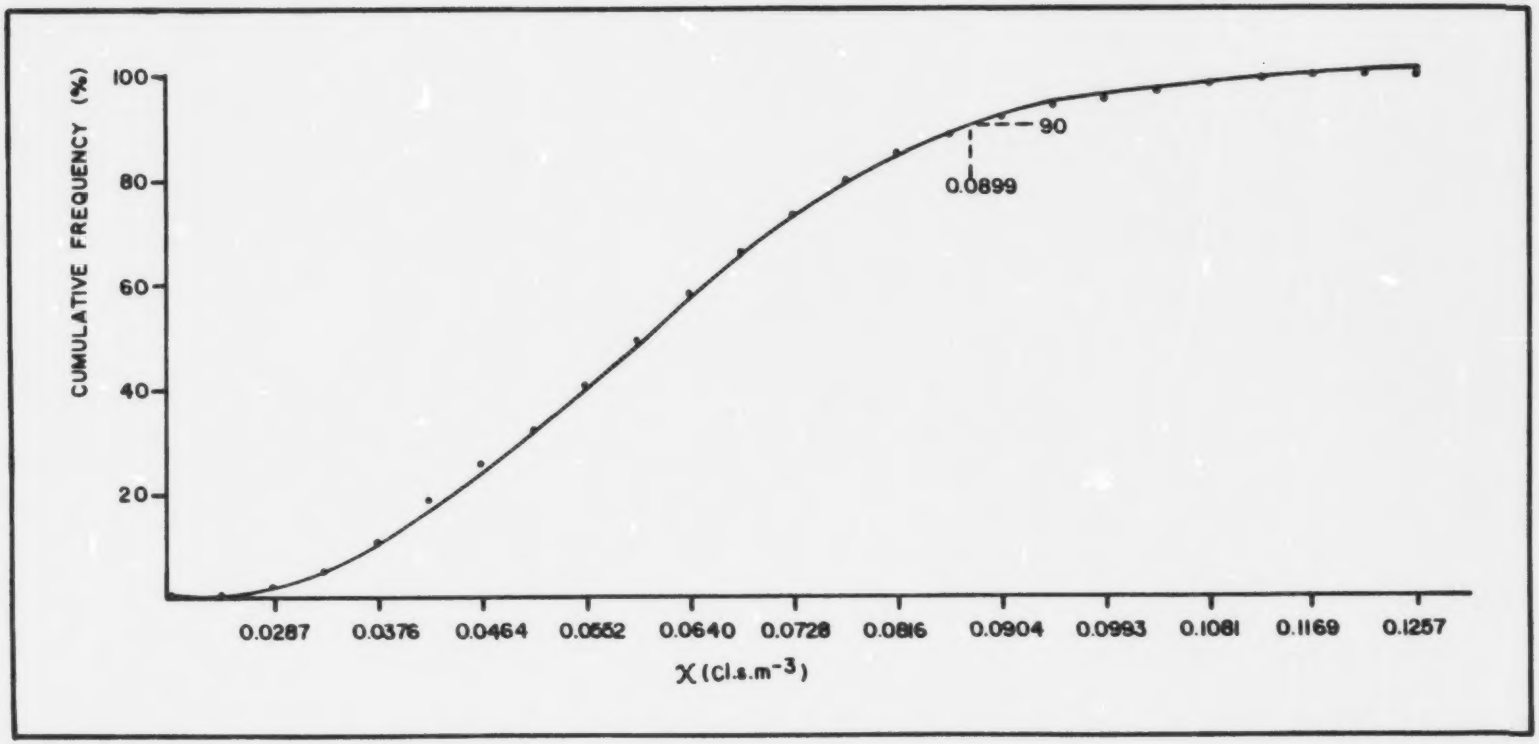

Figure E.1: Cumulative frequency distribution of $\chi_k$ for the ~42,000 720-hour scenarios (5 year data, St. John Airport, ground level release).

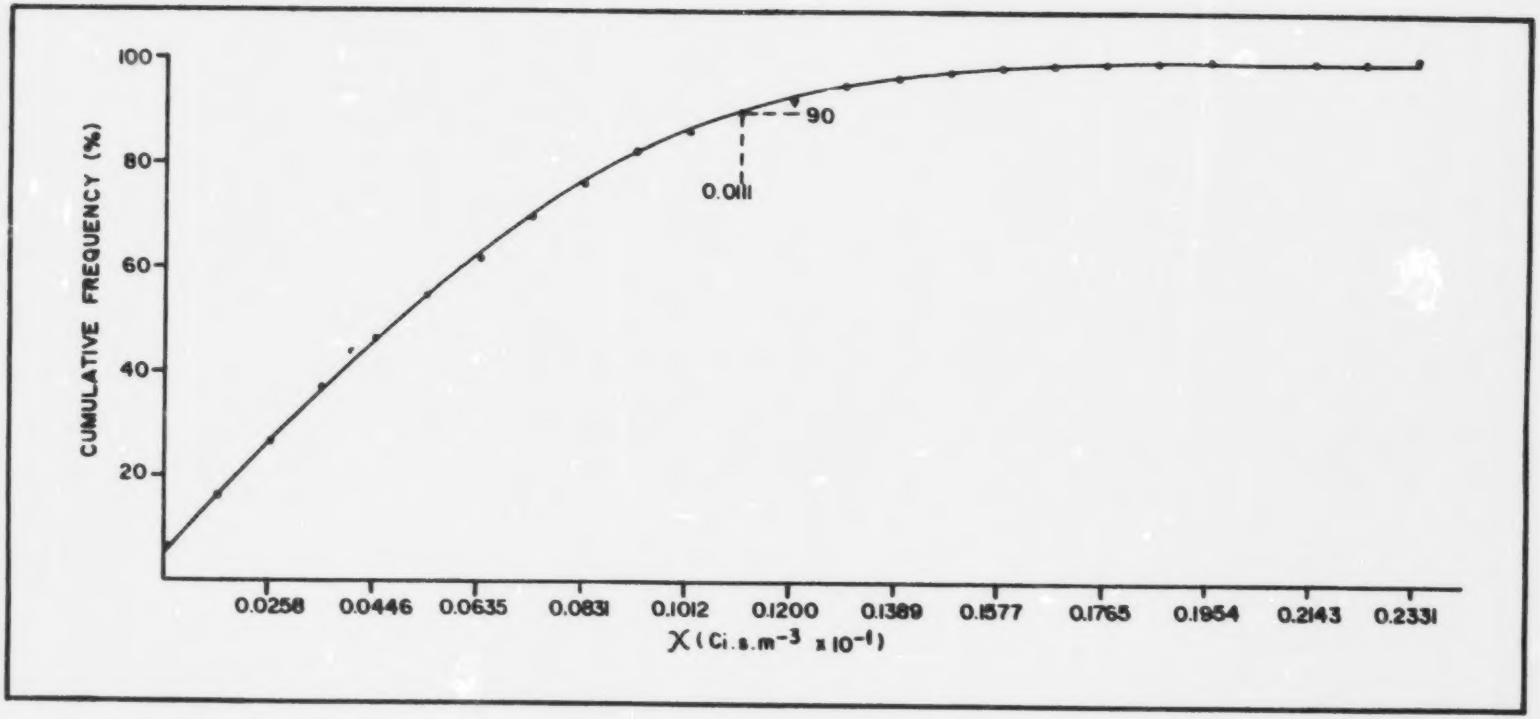

Figure E.2: Cumulative frequency distribution of $\chi_k$ for the ~42,000 72-hour scenarios (5 year data, St. John Airport, ground level release).

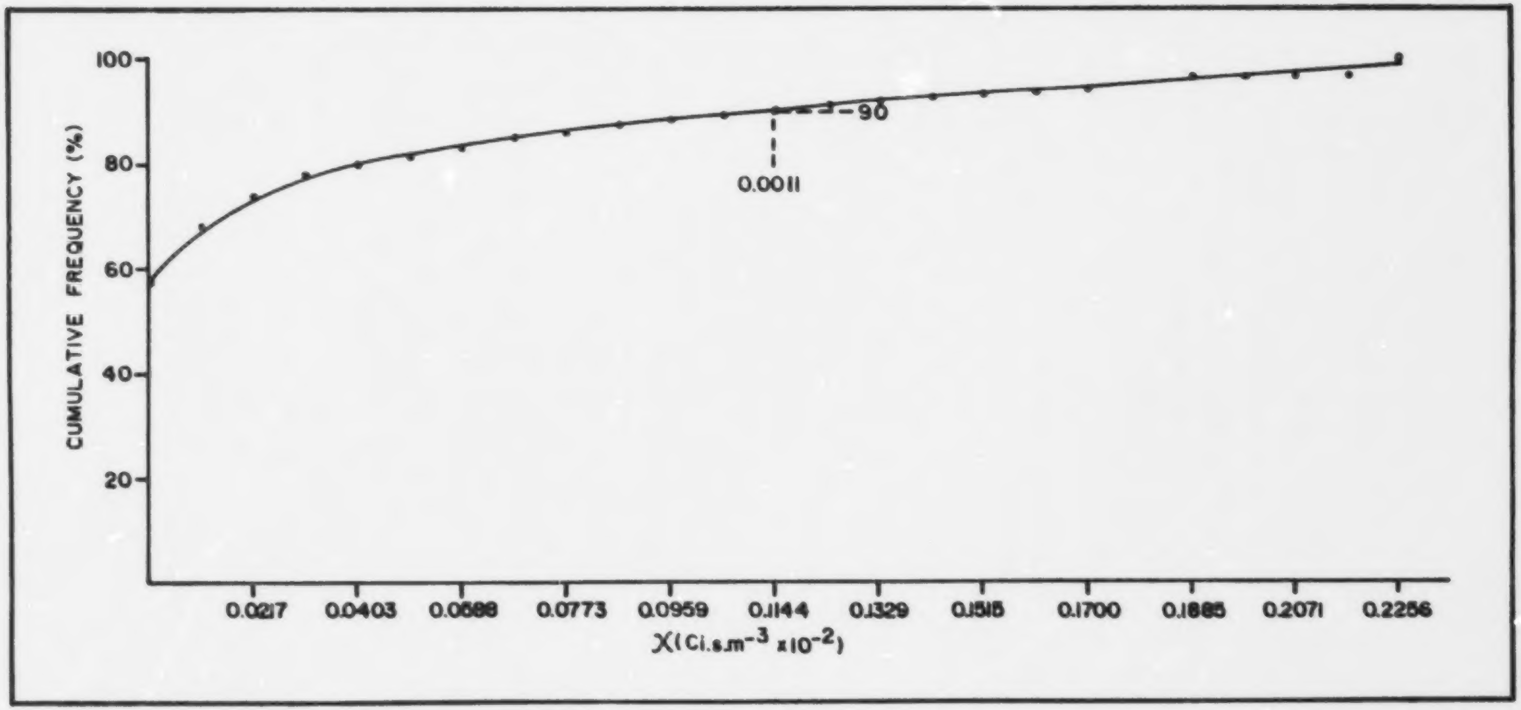

Figure E.3: Cumulative frequency distribution of $\chi_k$ for the ~42,000 4-hour scenarios (5 year data, St. John Airport, ground level release).

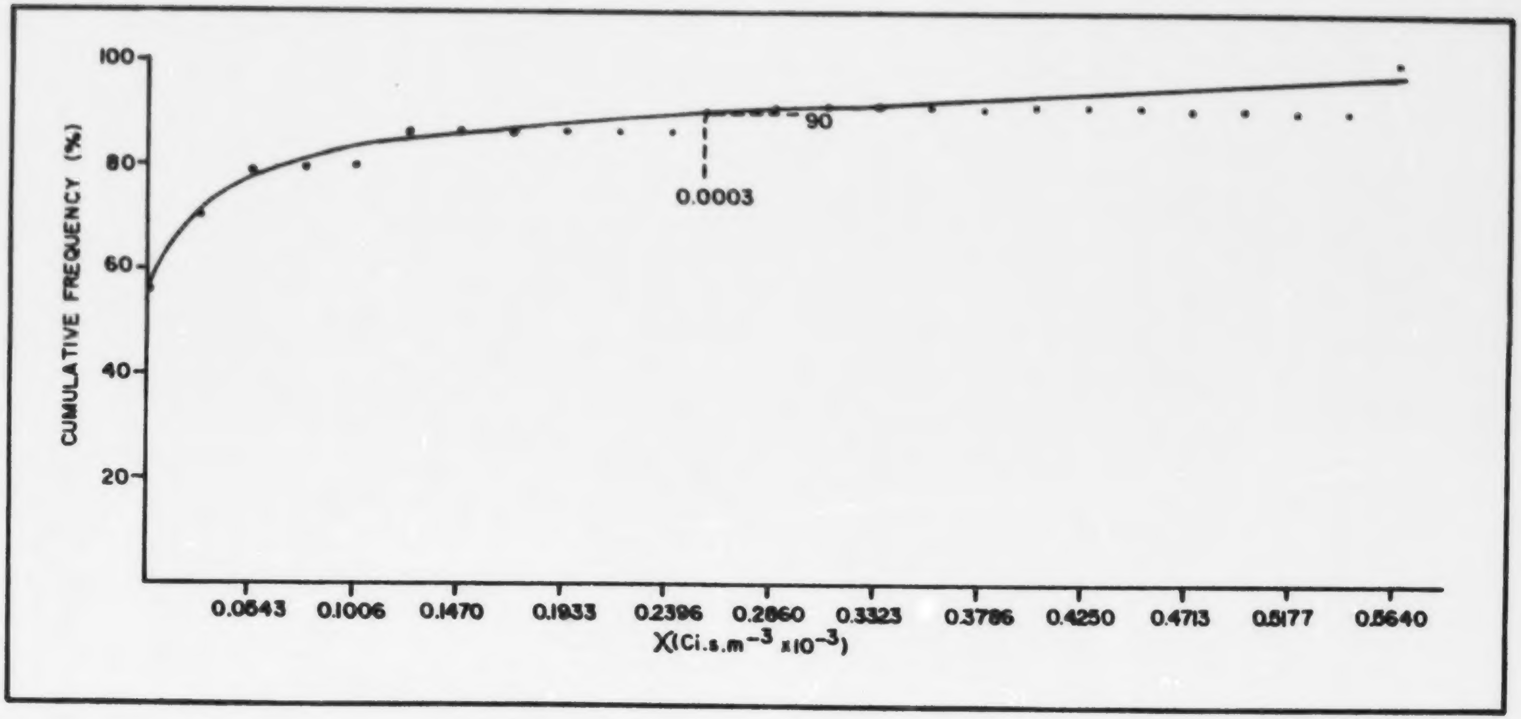

Figure E.4: Cumulative frequency distribution of $\chi_k$ for the ~42,000 1-hour scenarios (5 year data, St. John Airport, ground level release).

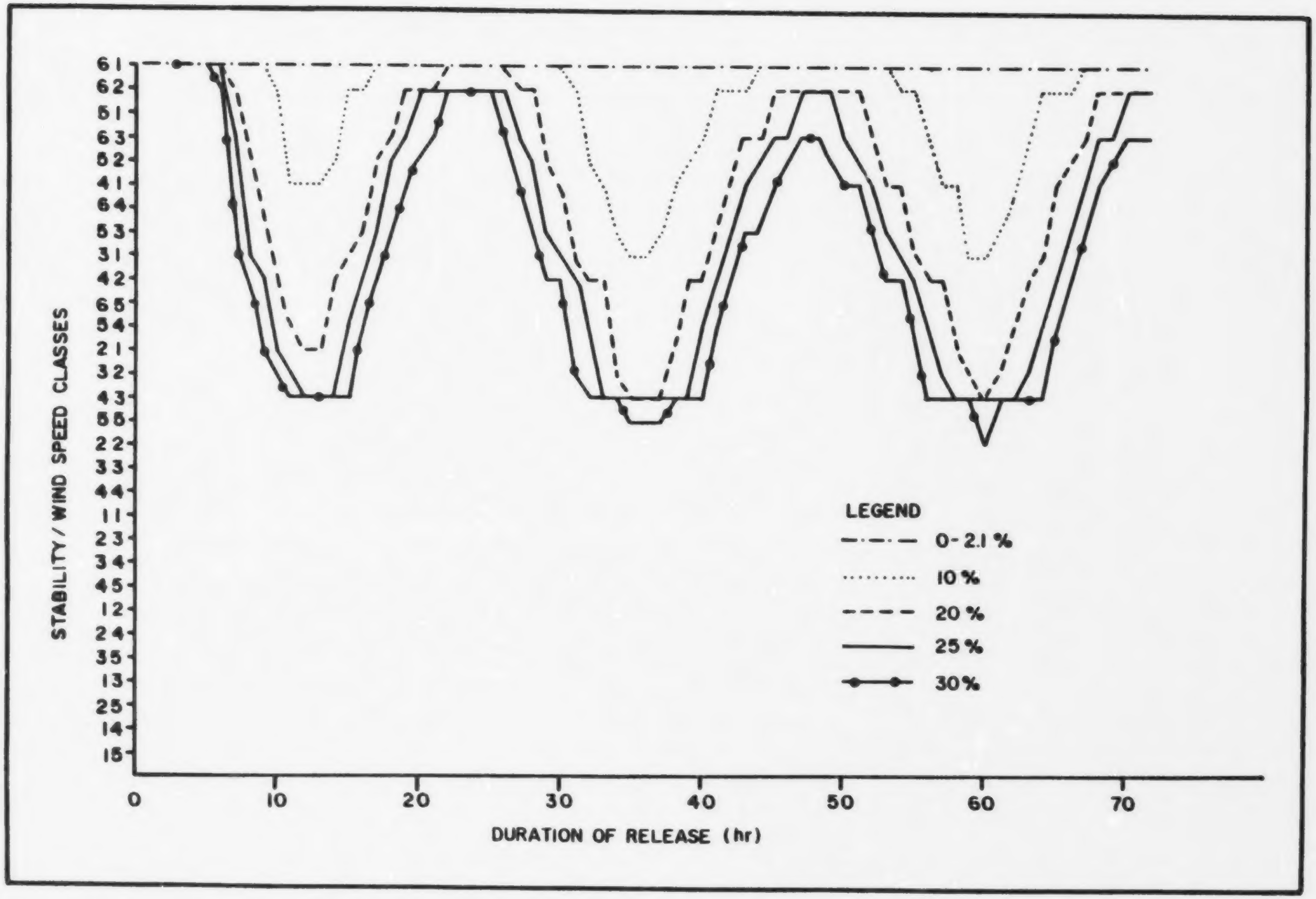

Figure E.5: 72-hour weather scenarios using various "percentage criteria" (5 year data, St. John Airport, ground level release).

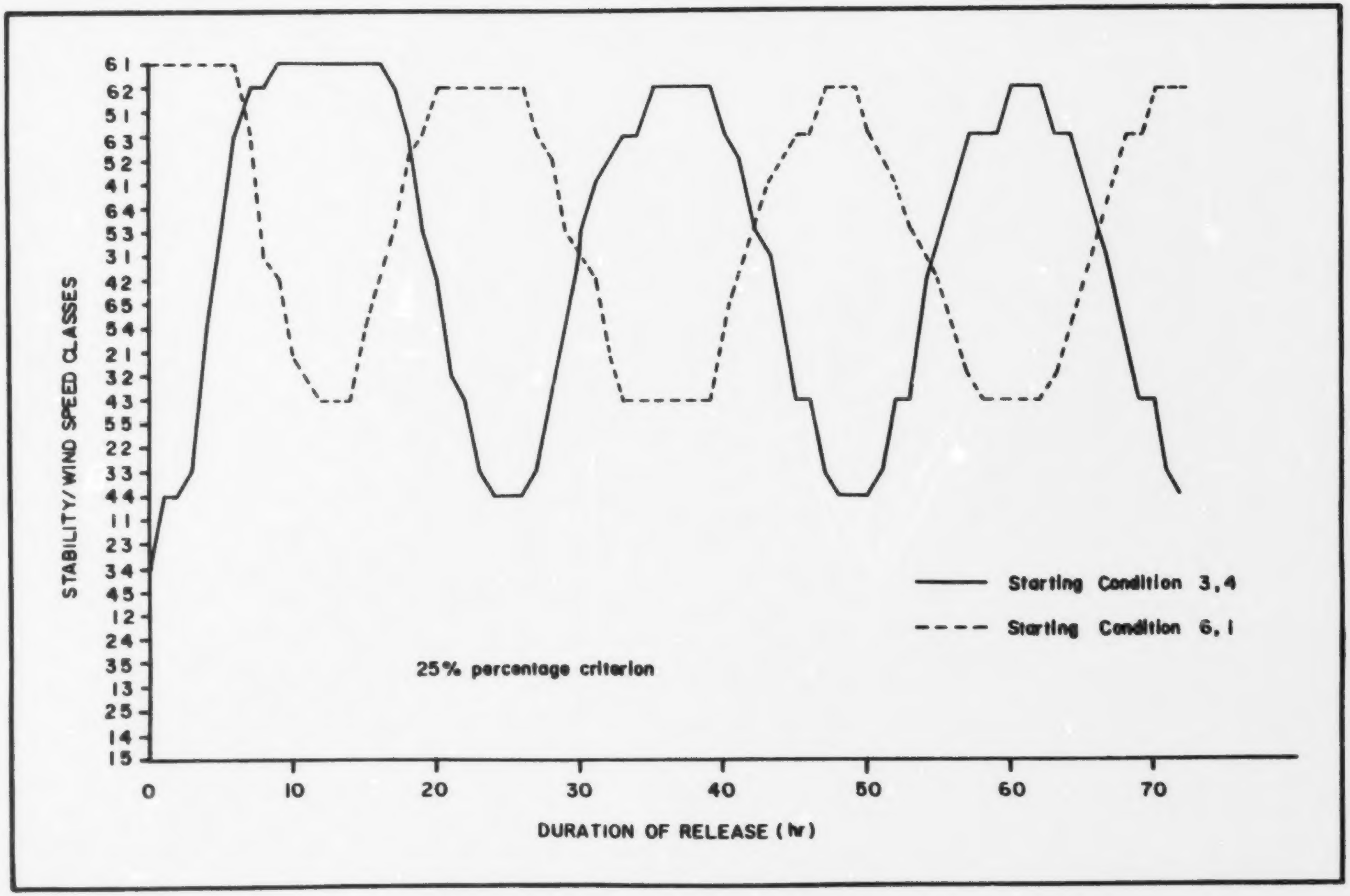

Figure E.6: Comparison of scenarios with different start conditions (5 year data, St. John Airport, ground level release).

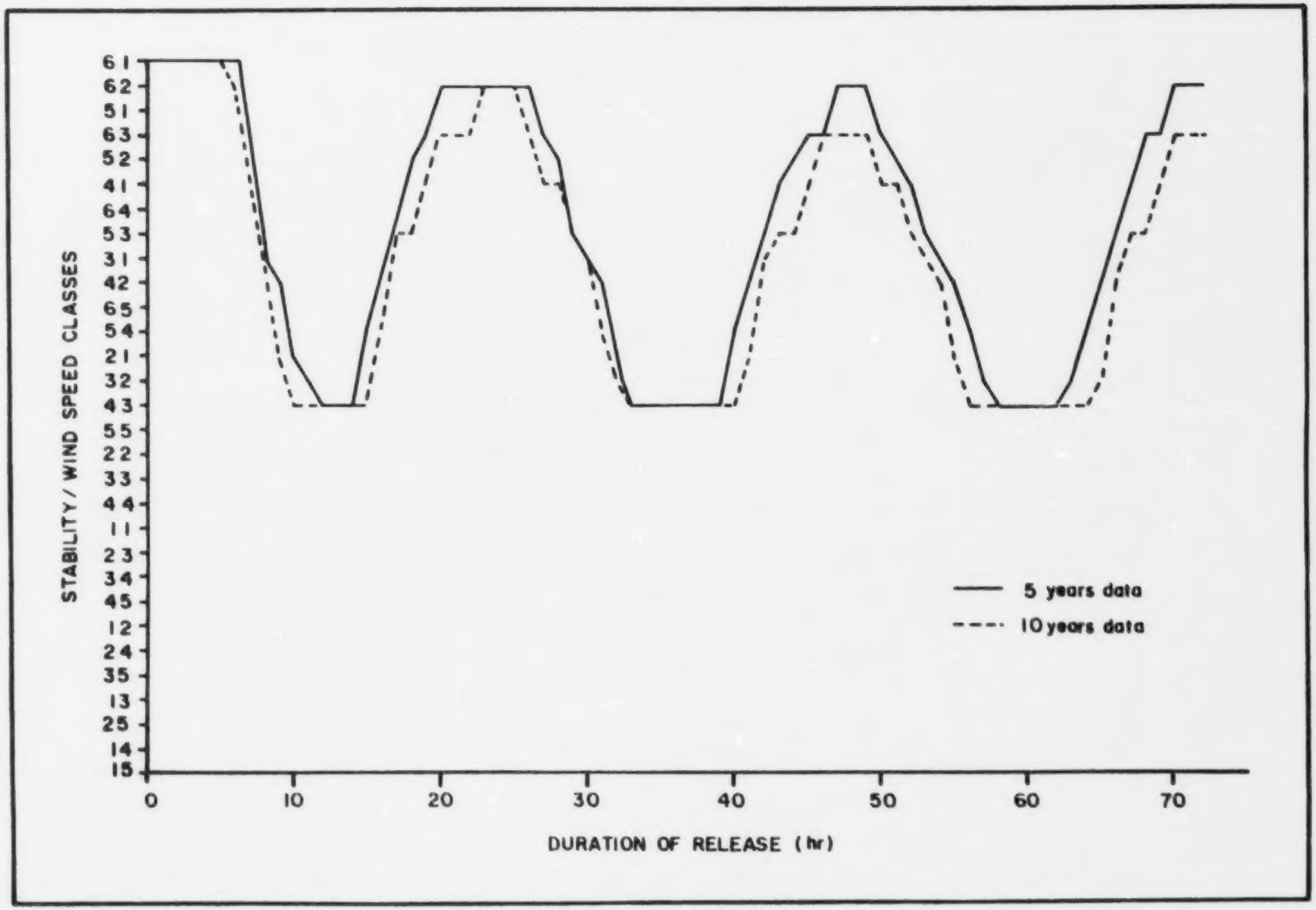

Figure E.7: Comparison of weather scenarios for St. John Airport using 5 years and 10 years of data for a 72-hour duration of release.

Figure E.8: Plot of Stability/Wind Speed vs Time from Release (Hours) 720 Hr. Duration, 5 Years Data
Ground Level Release, St. John Airport Met. Data

```
stability class/ wind speed and # of accurances

 61  62  51  63  52  41  64  53  31  42  65  54  21  32  43  55  22  33  44  11  23  34  45  12  24  35  13  25  14  15
  8 157   0  84  44  59   0  44  27  85   0  37  25  33 117   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

pattern analysis at 23.0 %
```

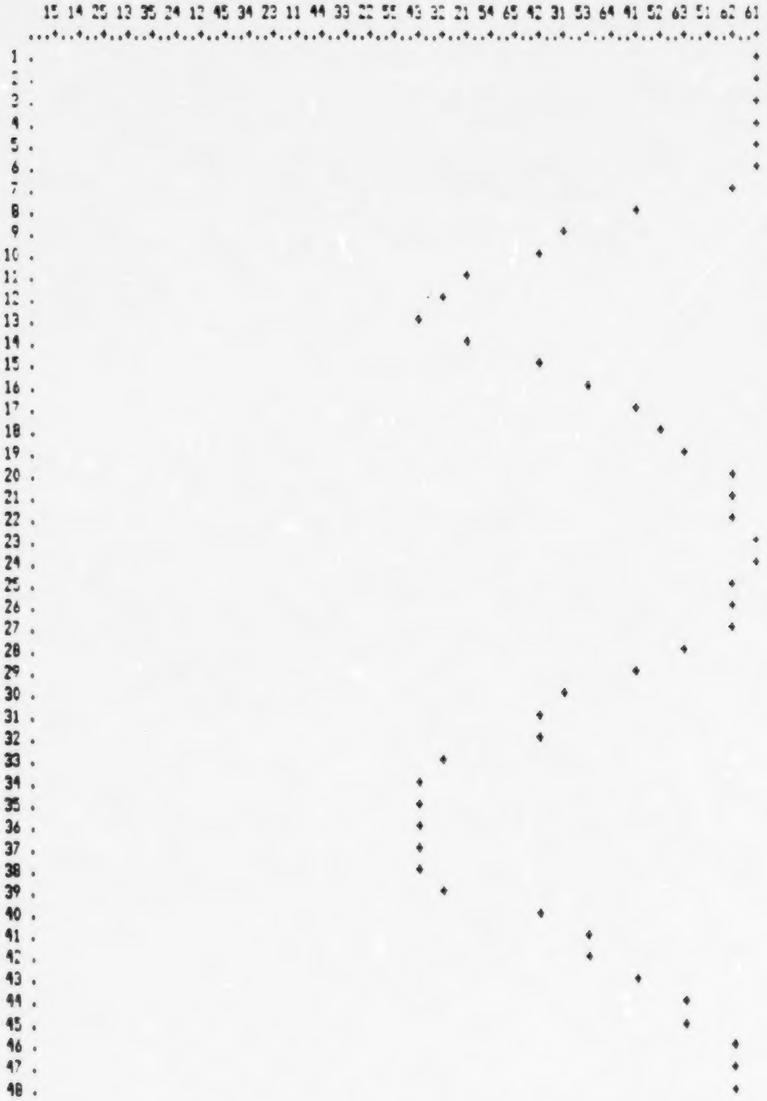

Figure E.8: cont'd/2

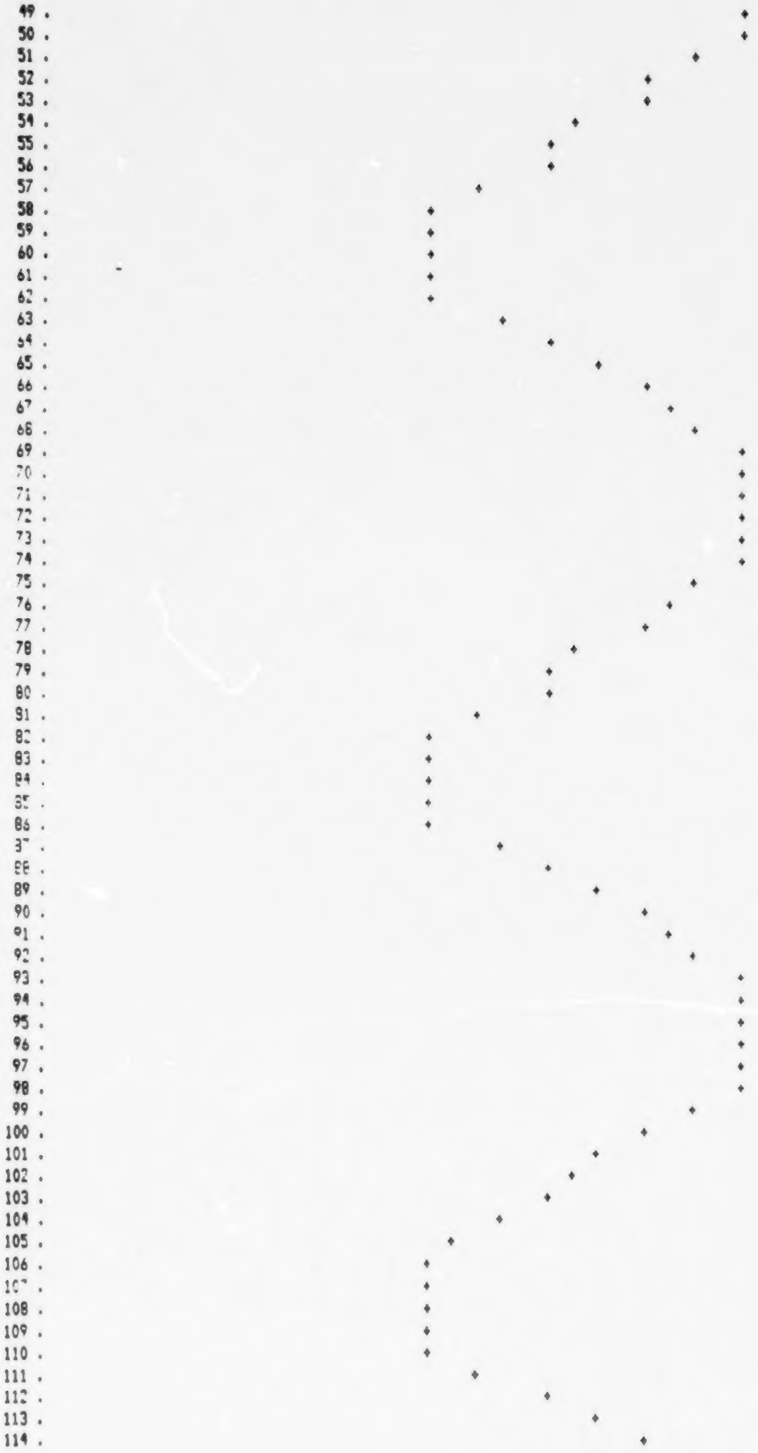

Figure E.8: cont'd/3

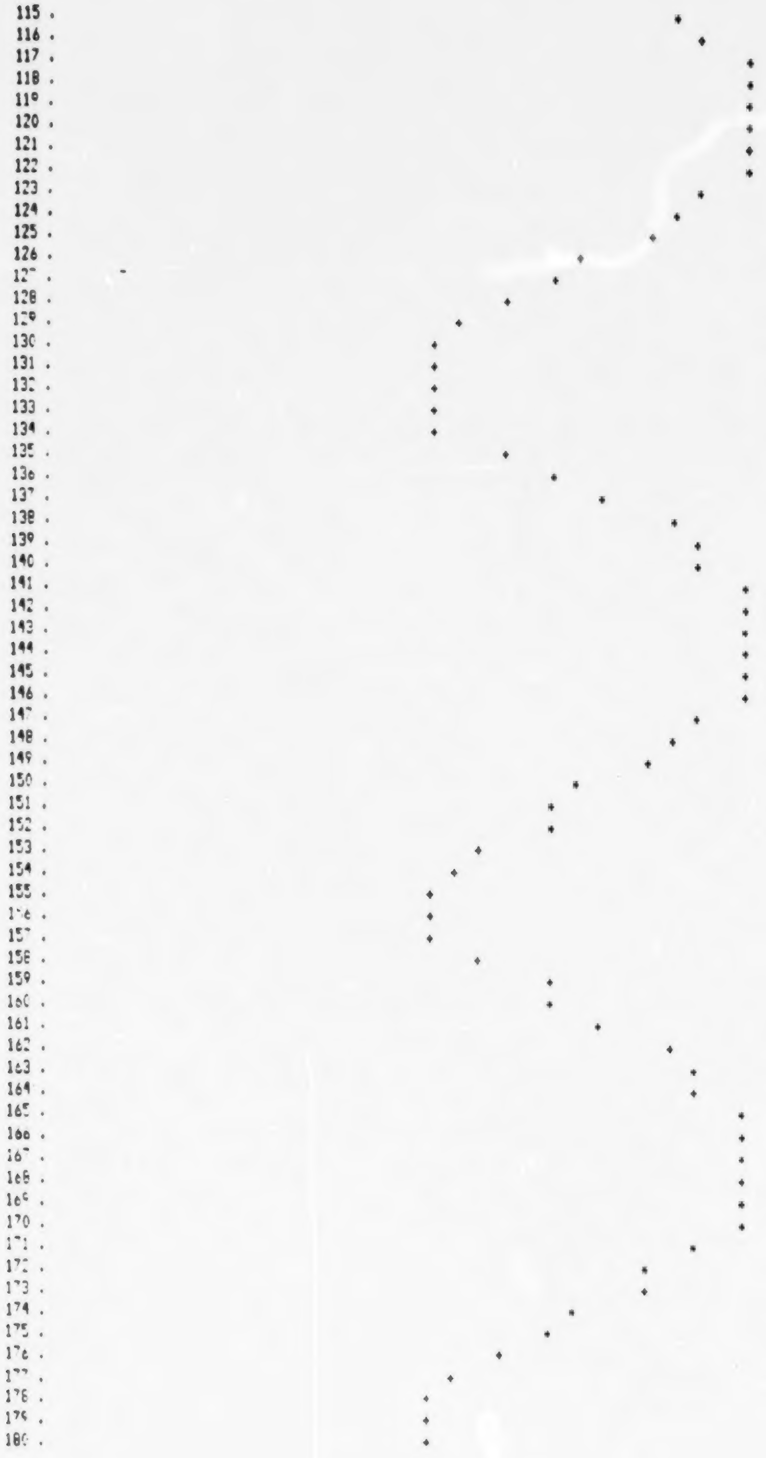

Figure E.8: cont'd/4

```
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183 .                  +
184 .                    +
185 .                      +
186 .                      +
187 .                        +
188 .                          +
189 .                          +
190 .                            +
191 .                            +
192 .                            +
193 .                            +
194 .                          +
195 .                         +
196 .                        +
197 .                        +
198 .                     +
199 .                    +
200 .                    +
201 .                 +
202 .               +
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238 .                            +
239 .                            +
240 .                            +
241 .                            +
242 .                            +
243 .                          +
244 .                         +
245 .                        +
246 .                     +
```

**Figure E.8:** cont'd/5

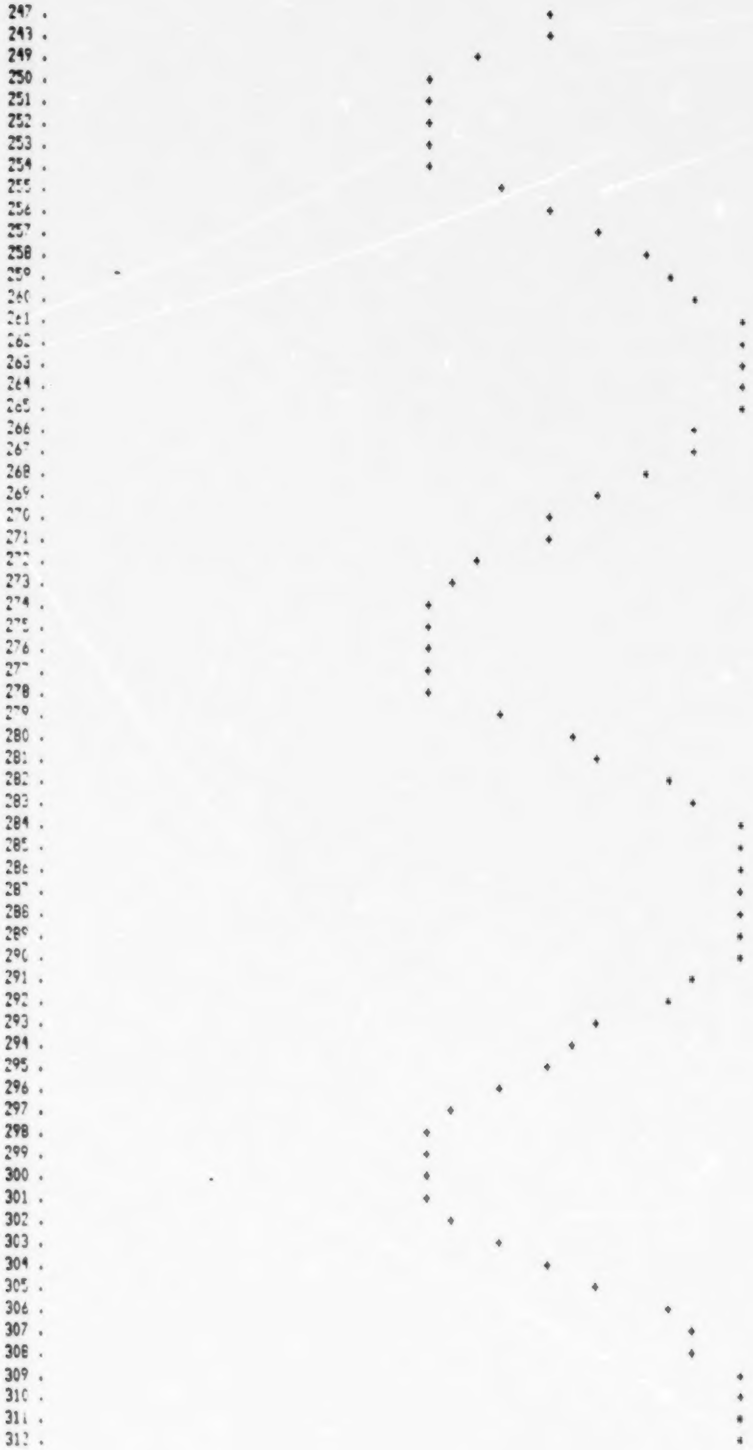

Figure E.8:  cont'd/6

```
313 .                                                                                       +
314 .                                                                                       +
315 .                                                                                 +
316 .                                                                              +
317 .                                                                           +
318 .                                                                  +
319 .                                                               +
320 .                                                               +
321 .                                                      +
322 .                                                +
323 .                                                +
324 .                                                +
325 .         -                                      +
326 .                                                   +
327 .                                                         +
328 .                                                               +
329 .                                                                     +
330 .                                                                           +
331 .                                                                              +
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333 .                                                                                       +
334 .                                                                                       +
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338 .                                                                                       +
339 .                                                                                 +
340 .                                                                           +
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355 .                                                                           +
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357 .                                                                                 +
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359 .                                                                                       +
360 .                                                                                       +
361 .                                                                                       +
362 .                                                                                 +
363 .                                                                              +
364 .                                                                           +
365 .                                                                     +
366 .                                                               +
367 .                                                               +
368 .                                                         +
369 .                                                +
370 .                                                +
371 .                                                +
372 .                                                +
373 .                                                +
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375 .                                                         +
376 .                                                               +
377 .                                                                     +
378 .                                                                           +
```

**Figure E.8:** cont'd/7

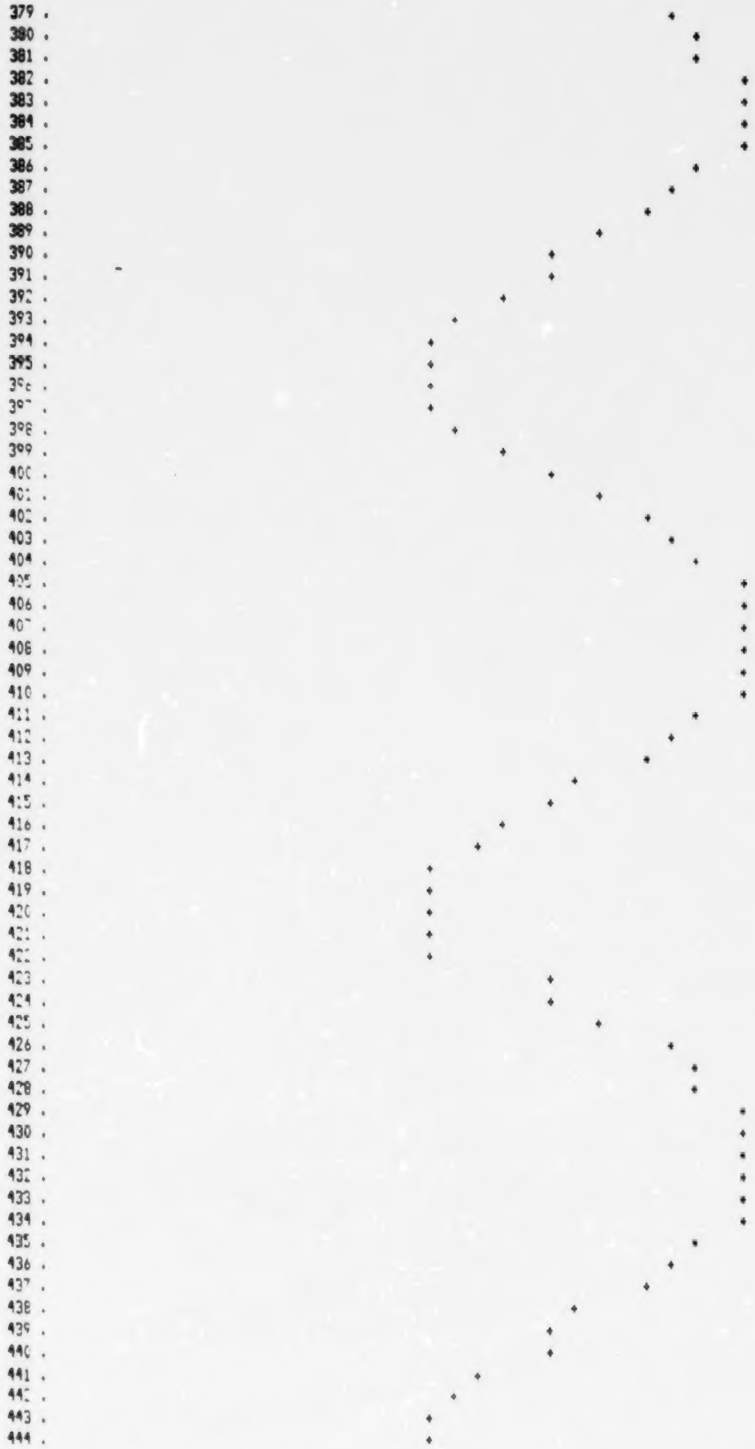


Figure E.8: cont'd/ 8

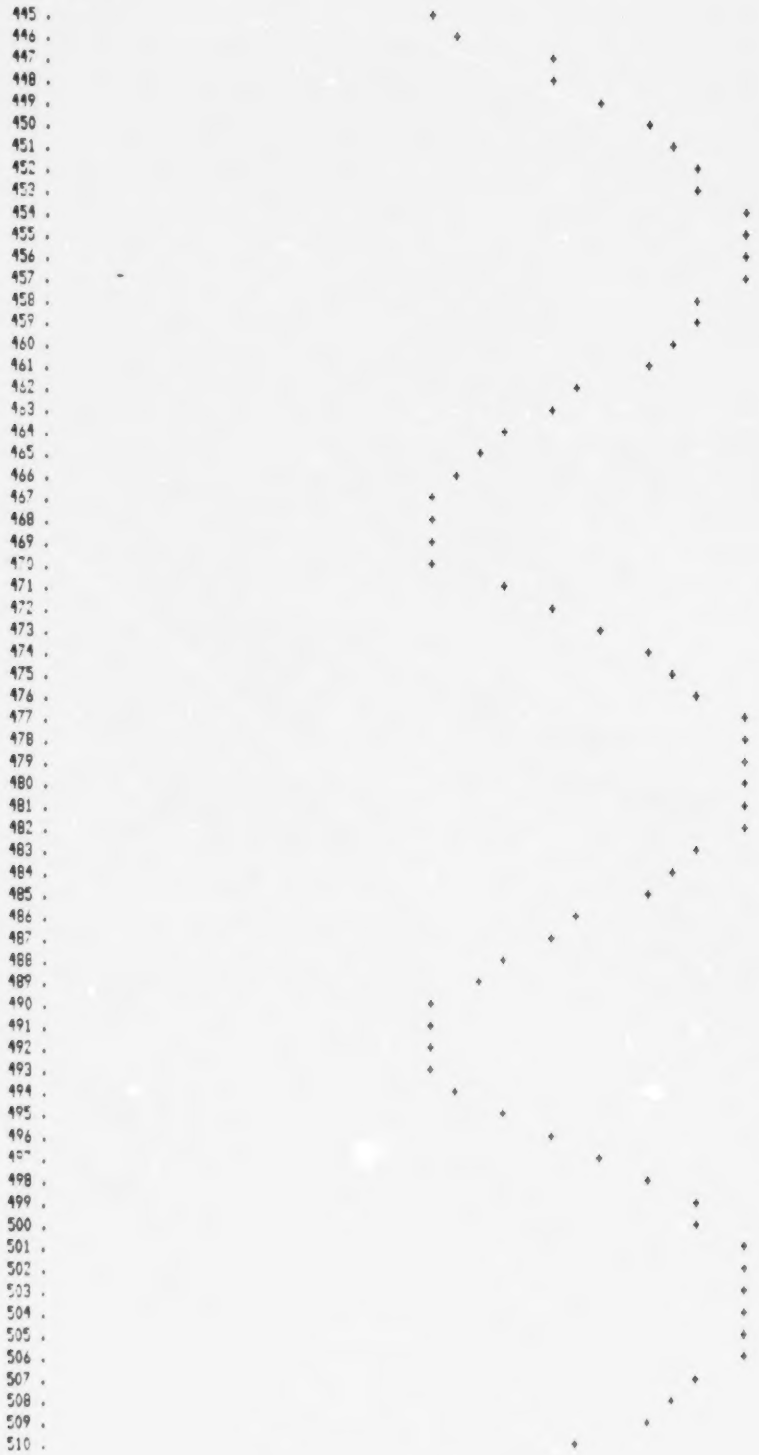


**Figure E.8:** cont'd/9

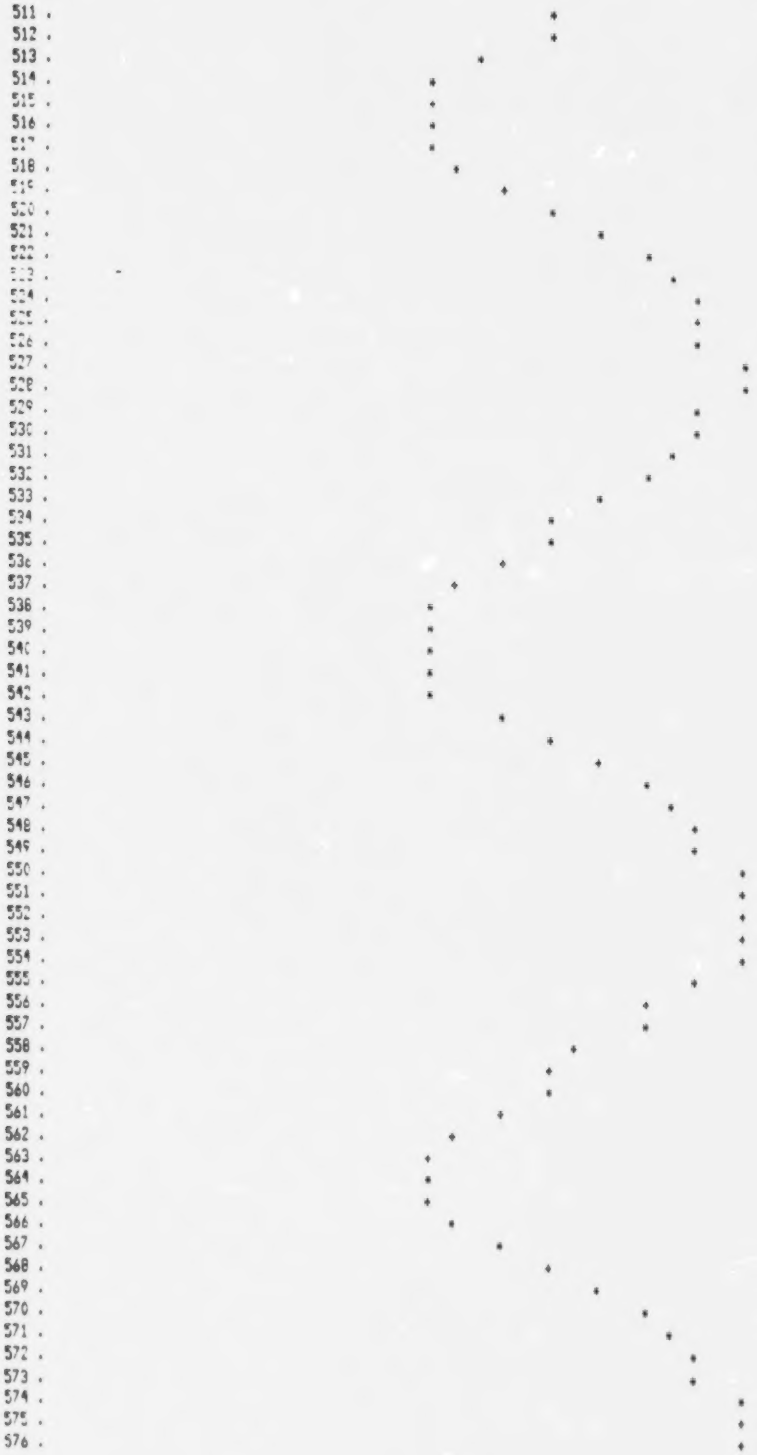


Figure E.8: cont'd/10

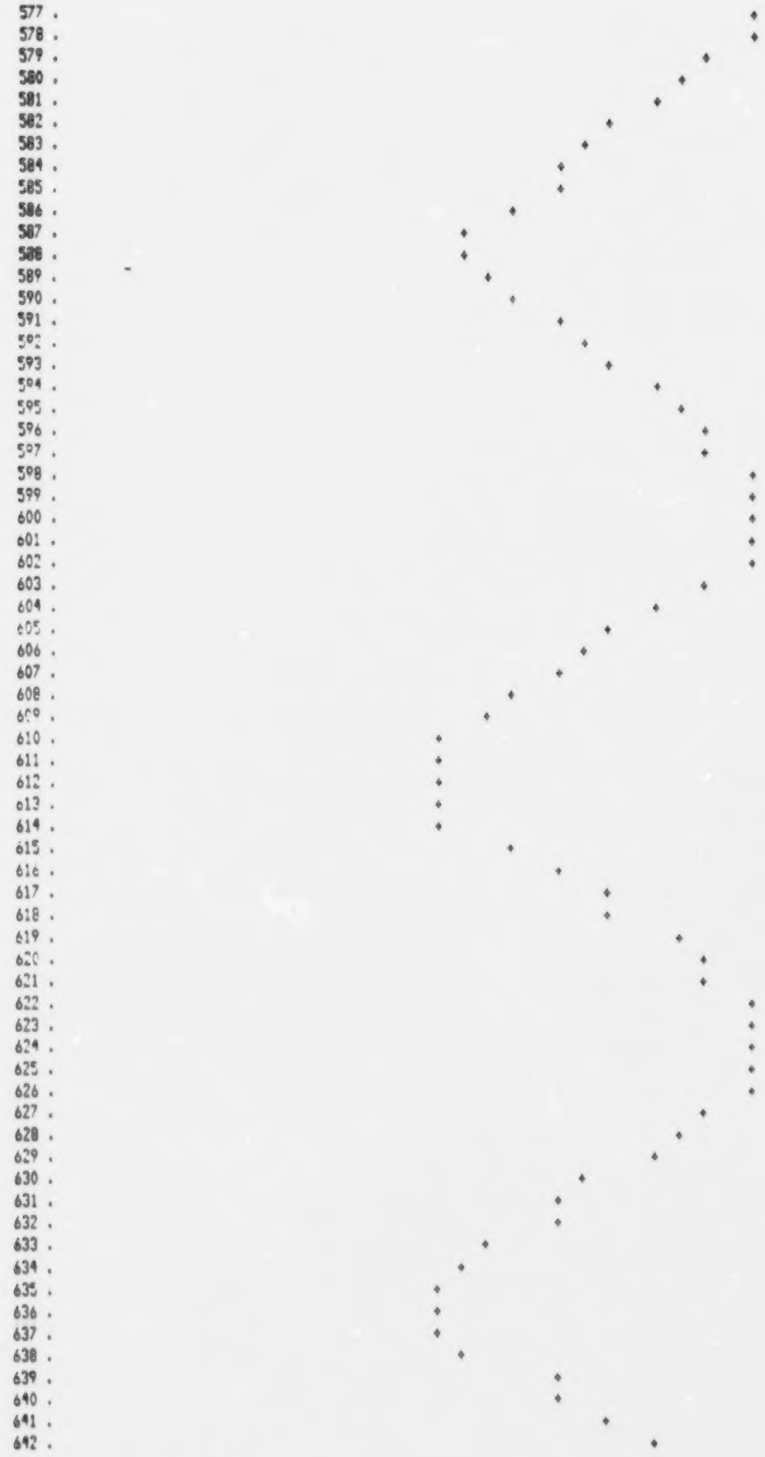


Figure E.8: cont'd/11

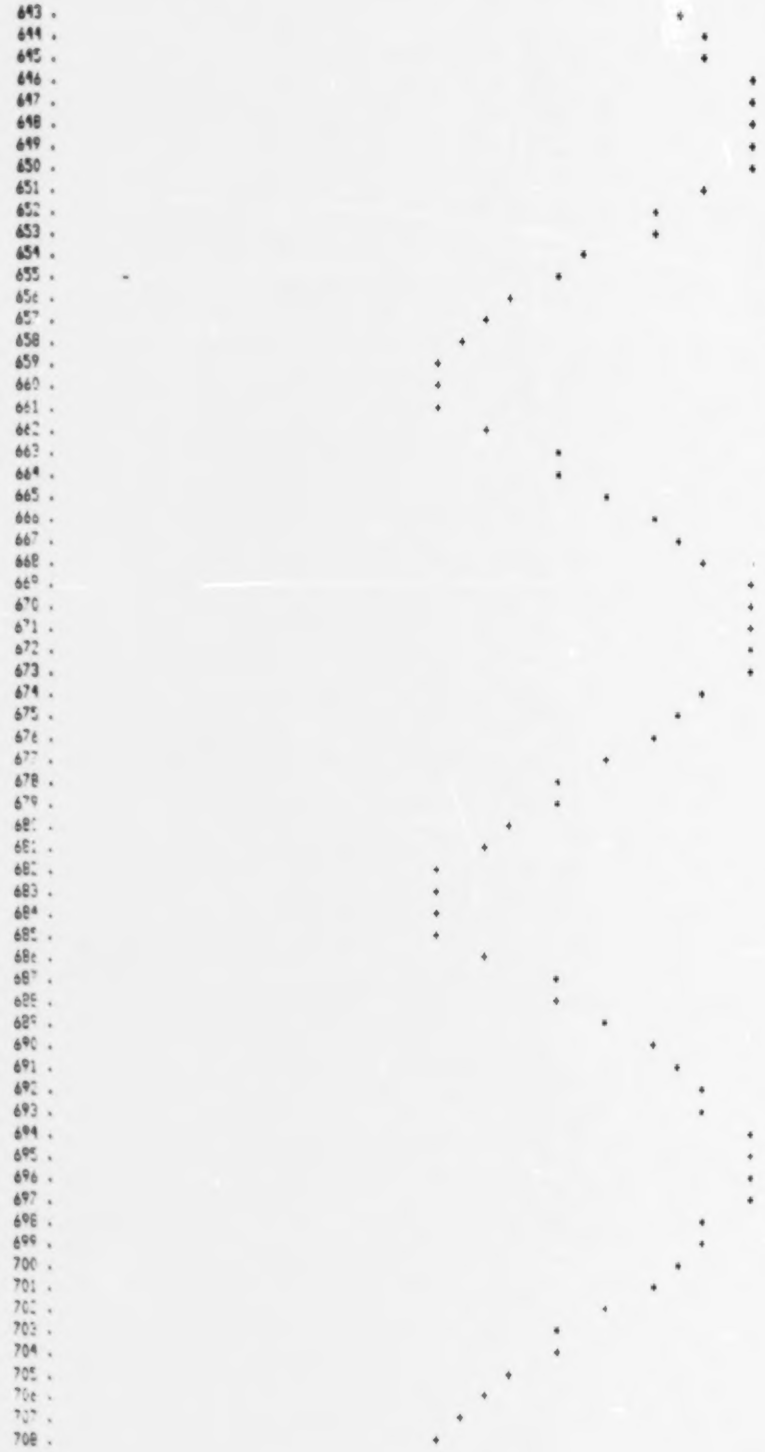


Figure E.8: cont'd/ 12

Figure E.9: Plot of Stability/Wind Speed vs Time from Release (Hours) 720 Hr. Duration, 5 Years Data
Elevated (50 m) Release, St. John Airport Met. Data 1 km Downwind Receptor

```
stability class/ wind speed and # of occurrences

 41  31  51  42  21  32  52  43  22  11  33  53  44  23  12  34  54  45  24  13  35  55  25  14  15  61  62  63  64  65
  3   1   0   3   0   1   1 143 101  38 139 235  55   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

pattern analysis at 25.0 %
```

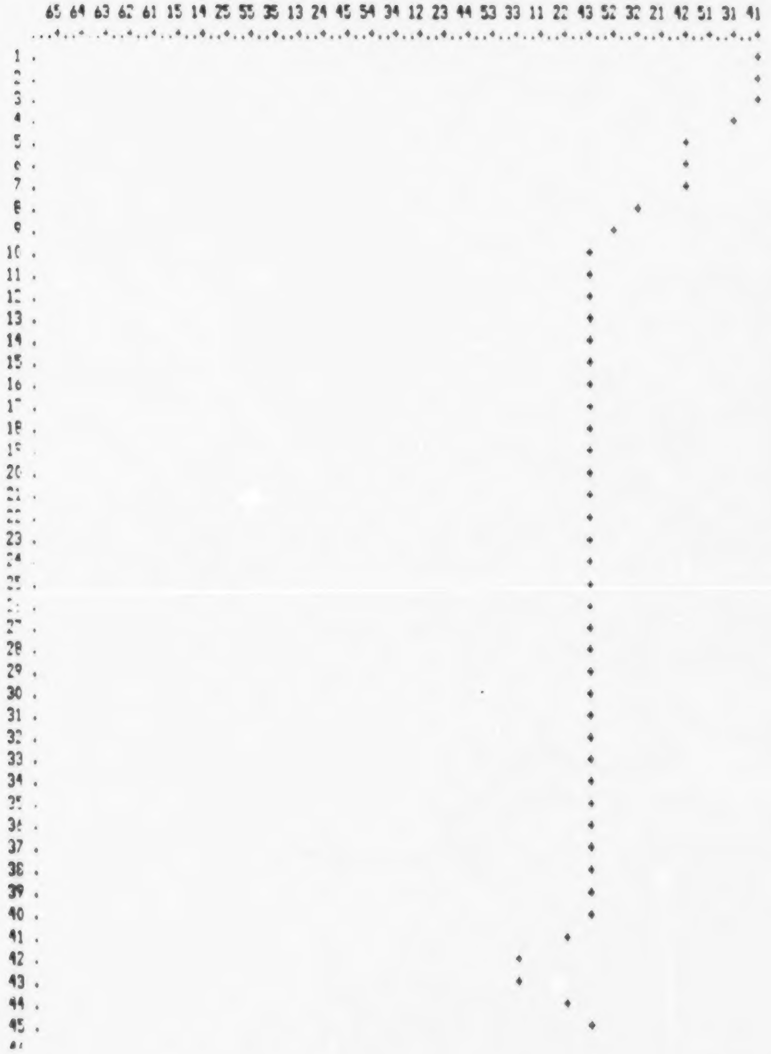


Figure E.9: cont'd/2

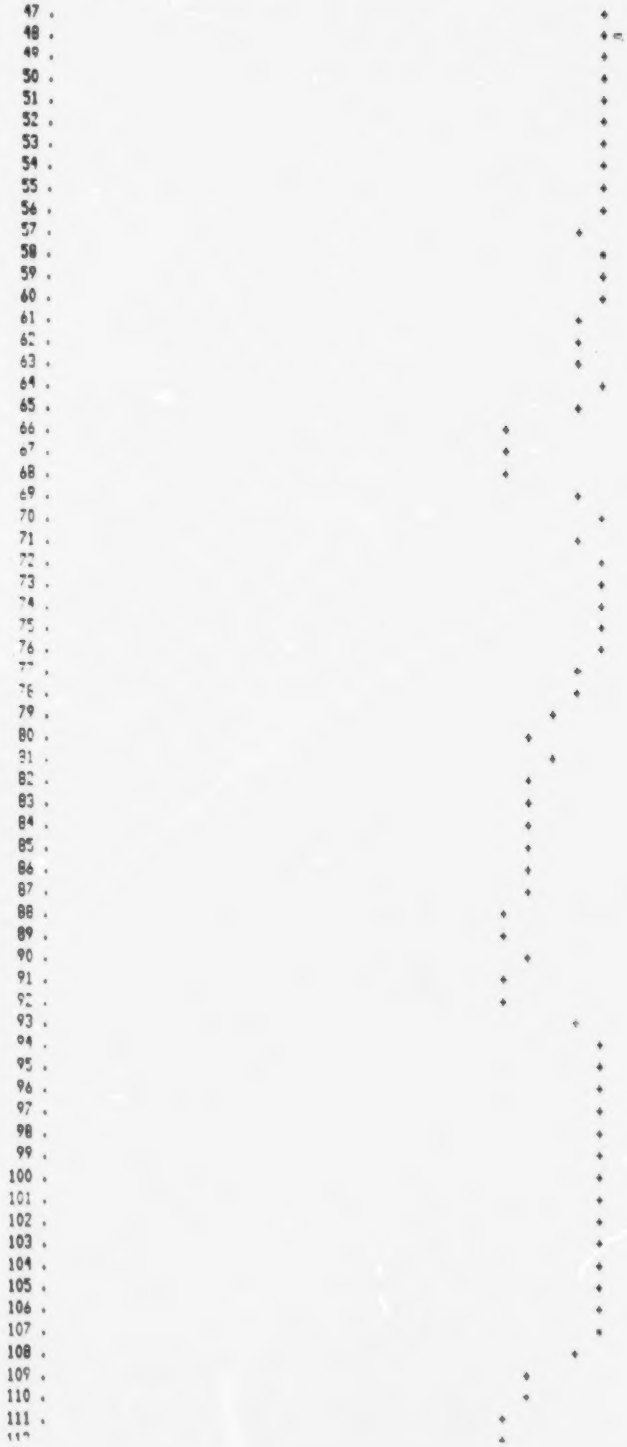


Figure E.9: cont'd/3

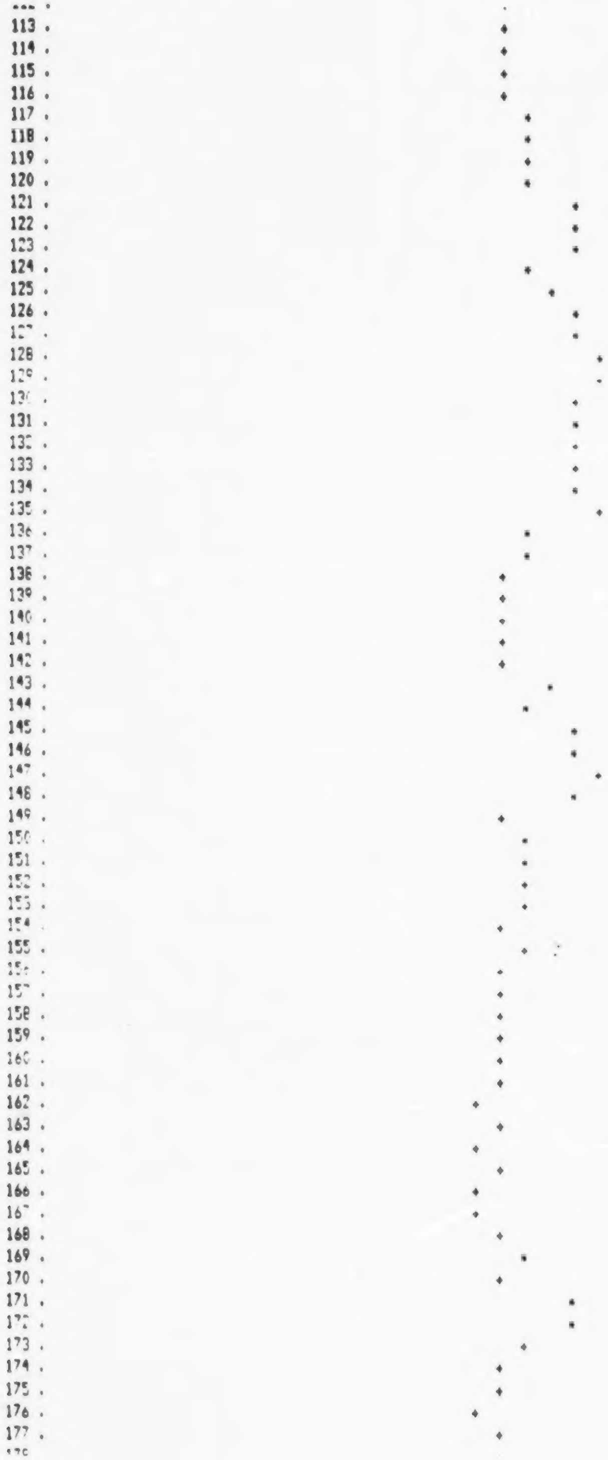
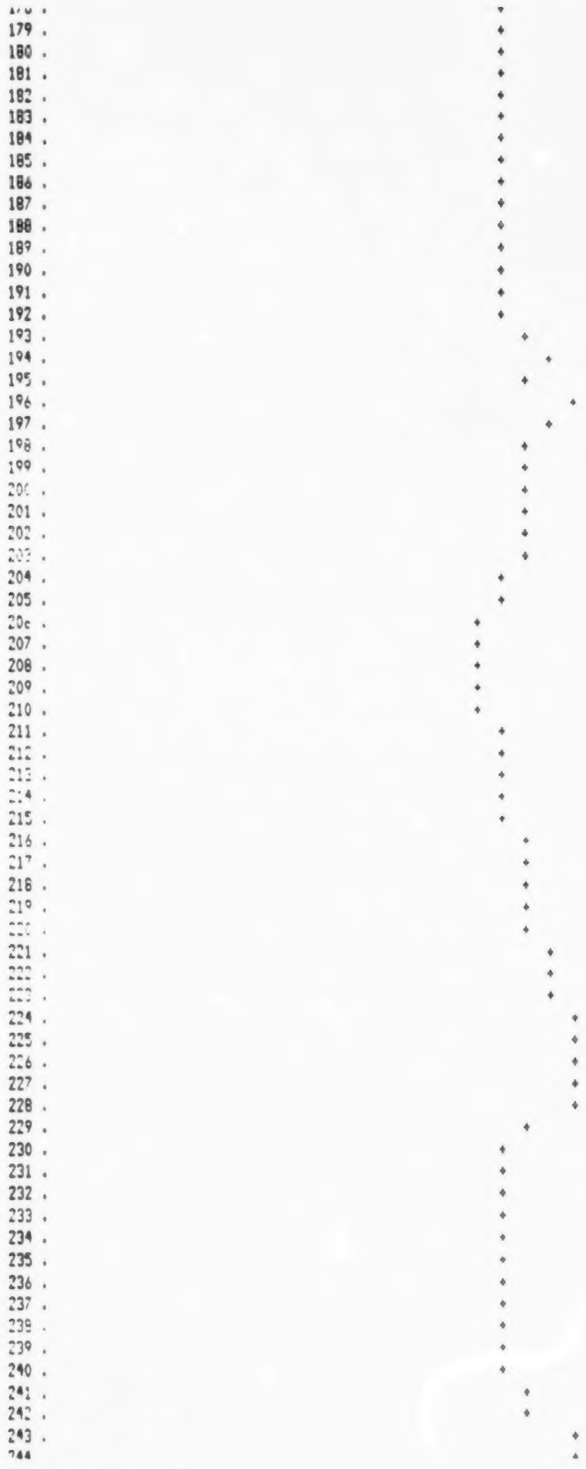


Figure E.9: cont'd/4



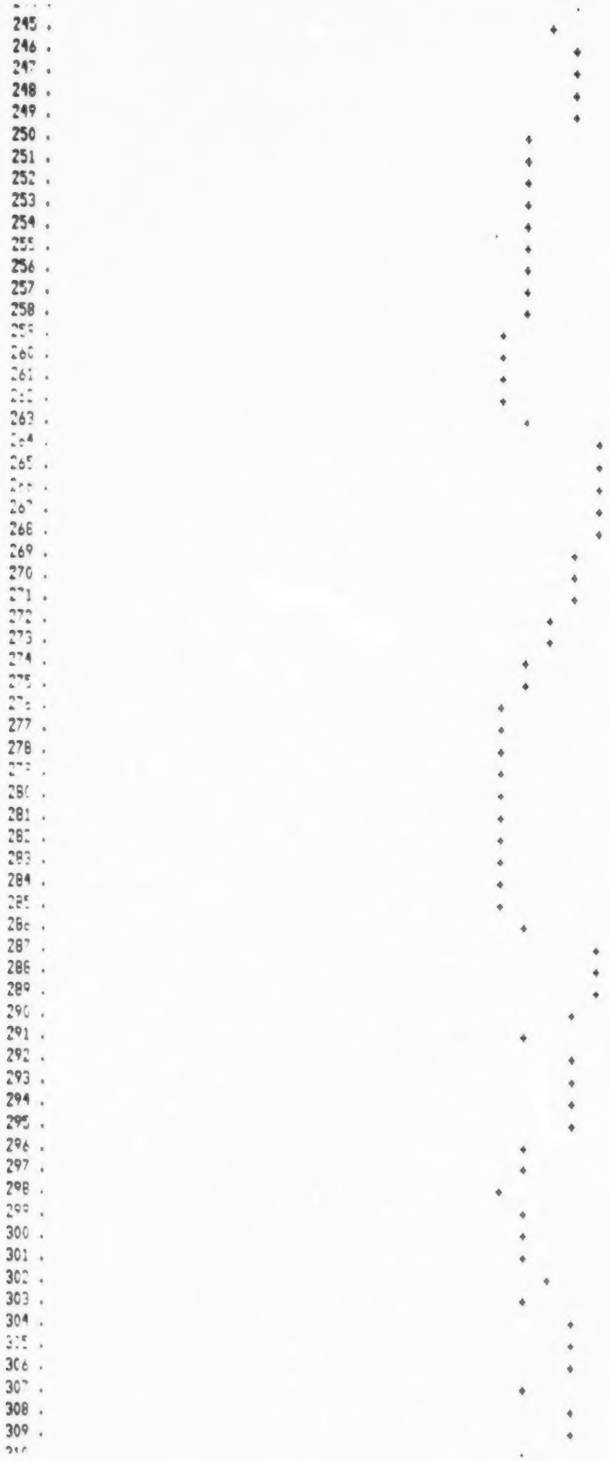


Figure E.9: cont'd/5

Figure E.9: cont'd/6

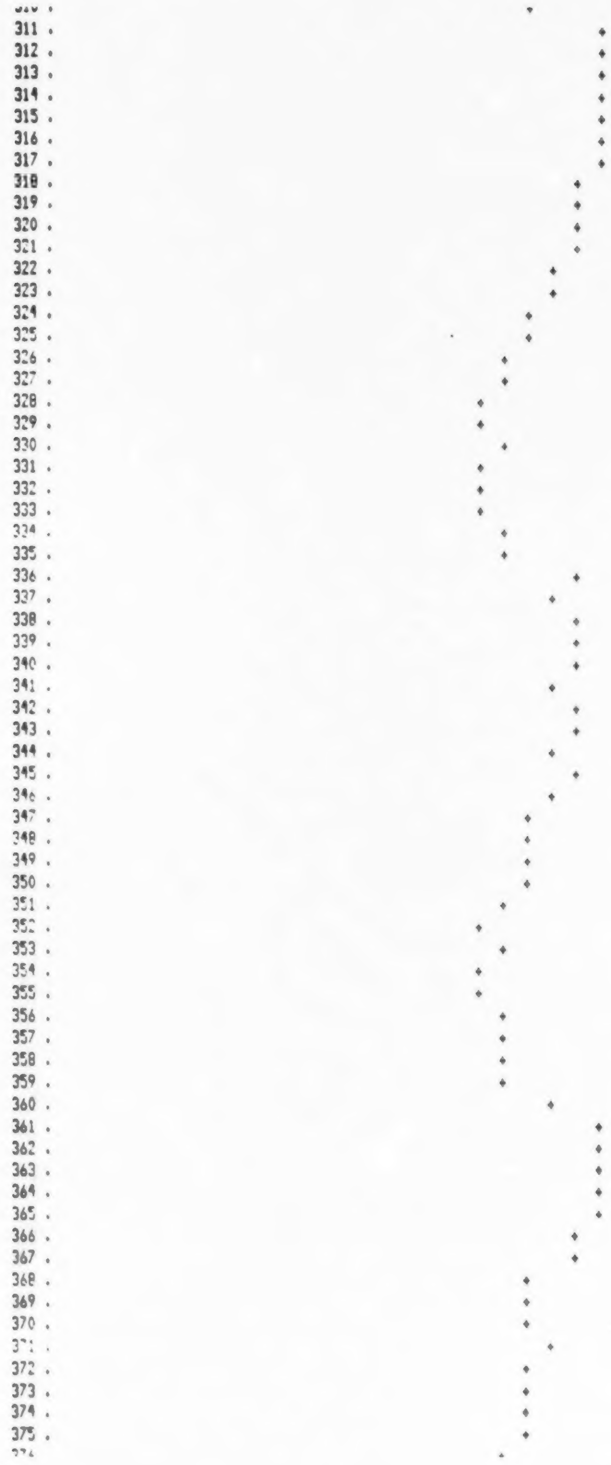


Figure E.9: cont'd/7

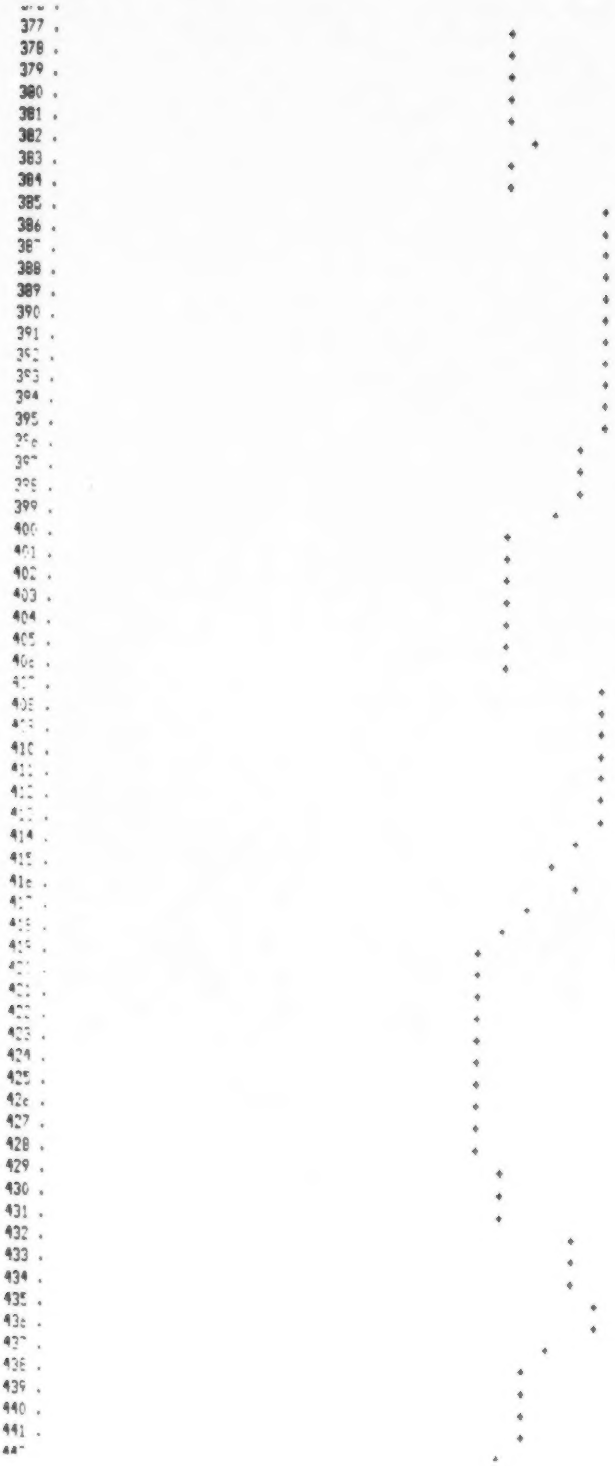


Figure E.9: cont'd/8

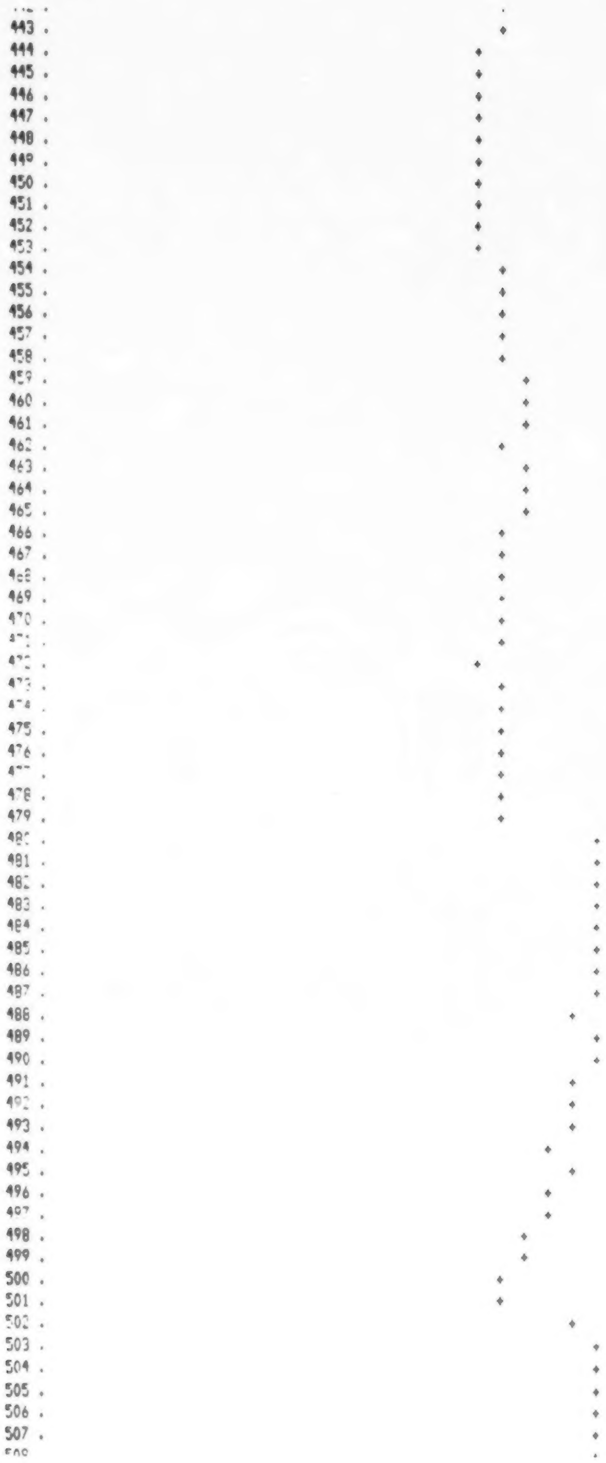


Figure E.9: cont'd/9

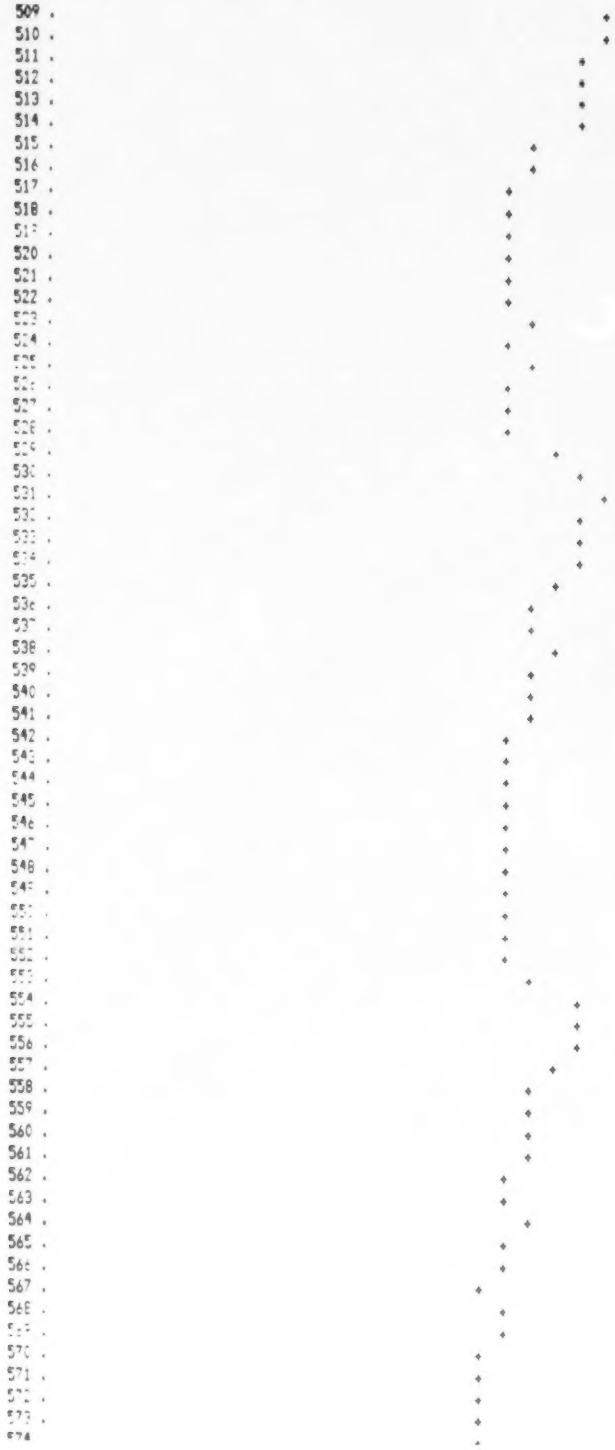


Figure E.9: cont'd/10

```
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577 .                   +
578 .                   +
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580 .                   +
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583 .                  +
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623 .                      +
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627 .                      +
628 .                      +
629 .                      +
630 .                      +
631 .                      +
632 .                     +
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635 .                   +
636 .                   +
637 .                   +
638 .                  +
639 .                  +
```

Figure E.9: cont'd/11

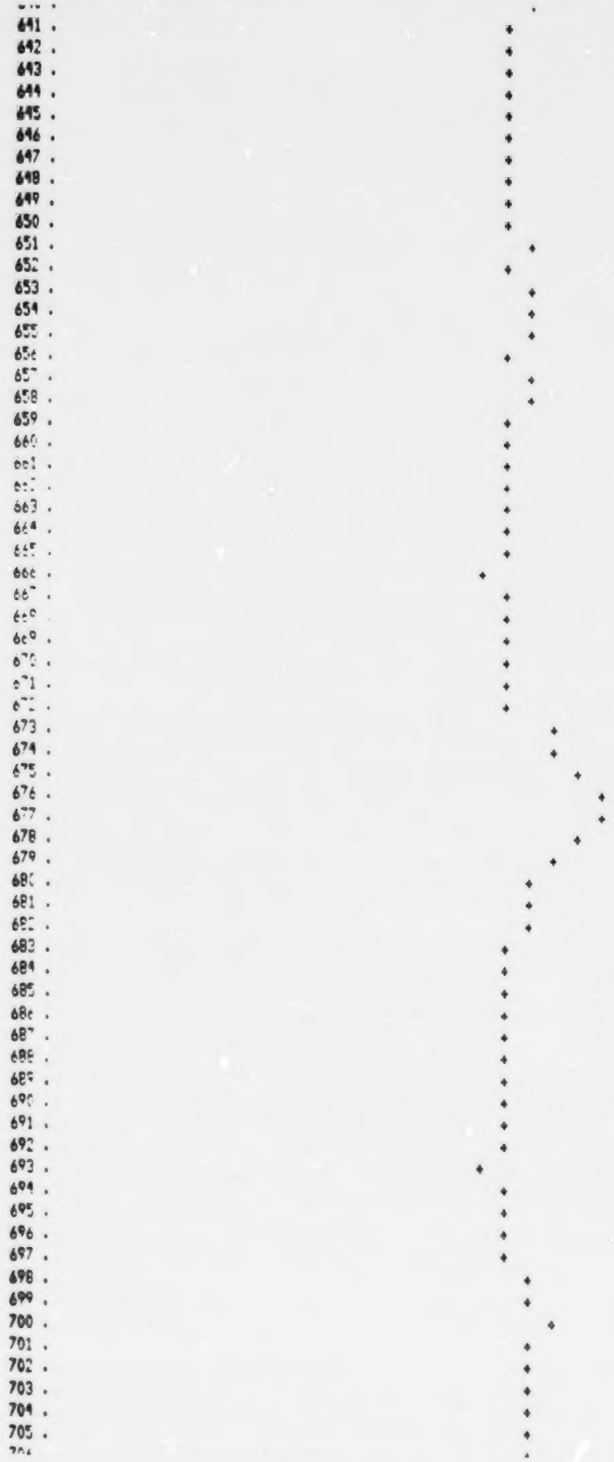

Figure E.9: cont'd/ 12

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    .                                                           +
707 .                                                           +
708 .                                                           +
709 .                                                        +
710 .                                                        +
711 .                                                     +
712 .                                                     +
713 .                                                     +
714 .                                                     +
715 .                                                        +
716 .                                                     +
717 .                                                     +
718 .                                                        +
719 .                                                        +
720 .                                                        +
```

Figure E.10: Plot of Stability/Wind Speed vs Time from Release (Hours) 720 Hr. Duration, 5 Years Data
Elevated (50 m) Release, St. John Airport Met. Data 3 km Downwind Receptor

```
stability class/ wind speed and # of occurrences

 51  61  41  52  62  31  42  53  63  32  43  21  54  64  33  44  22  55  11  65  34  45  23  12  35  24  13  25  14  15
  0   5   2   3 175  24 100  61  48  16 226  35  22   0   3   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

pattern analysis at 20.0 %
```

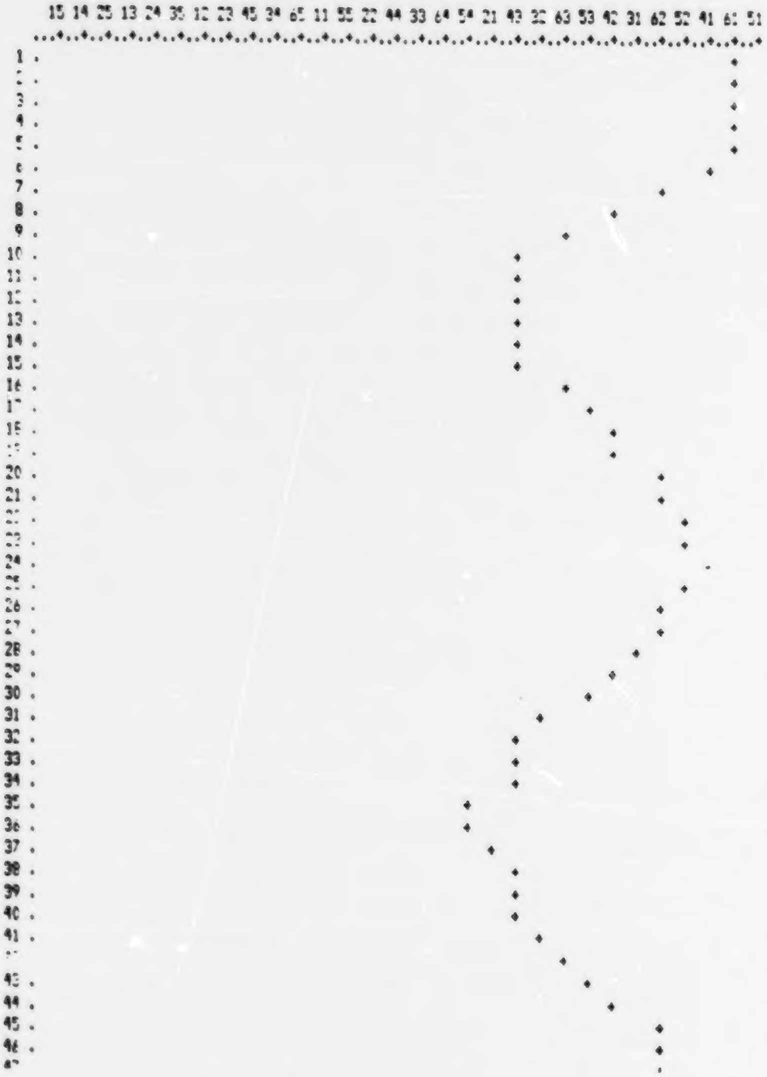

Figure E.10: cont'd/2

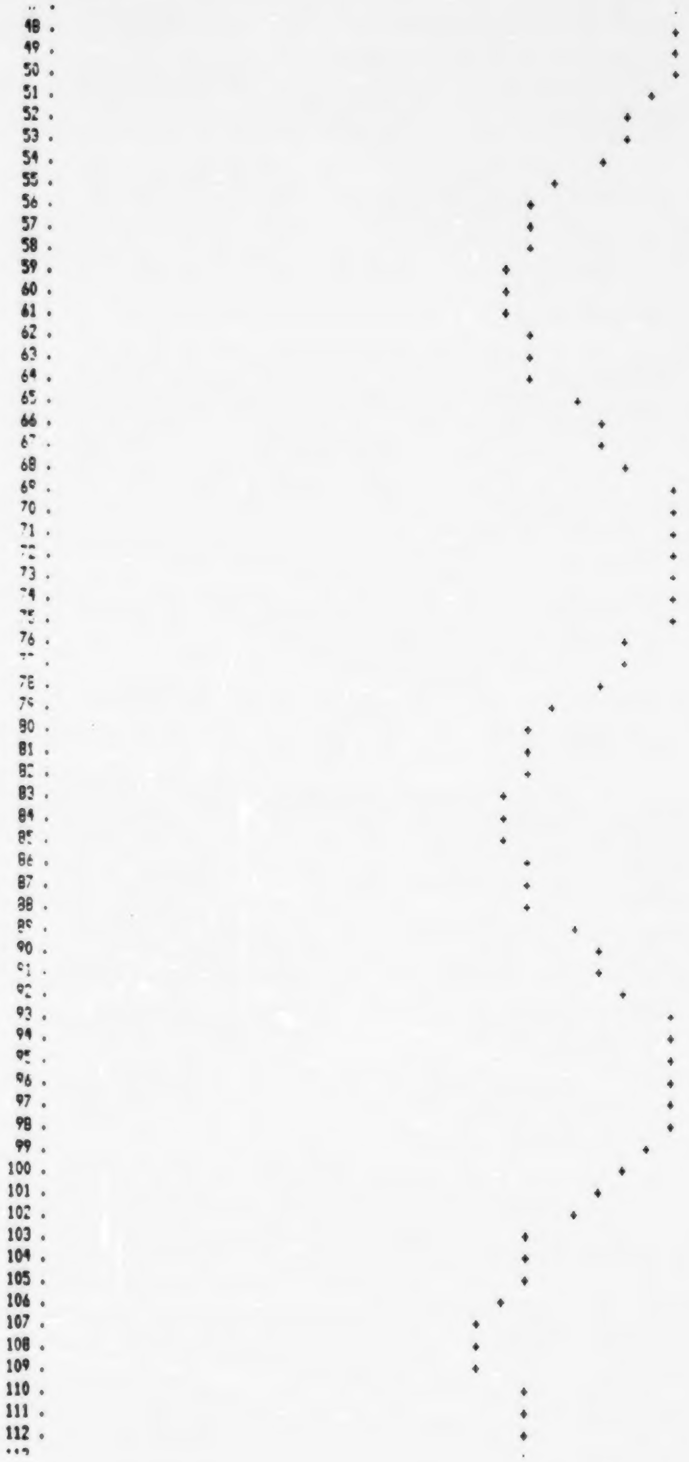

**Figure E.10:** cont'd/ 3

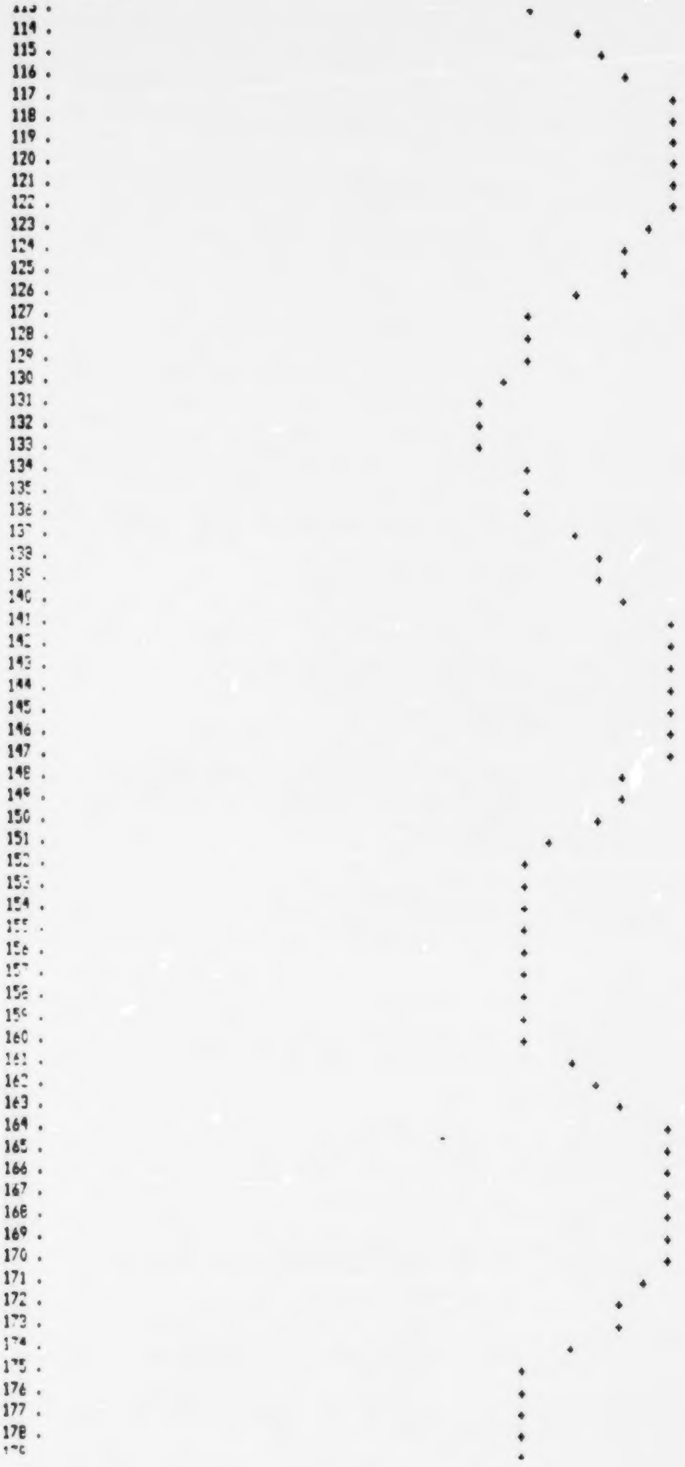

Figure E.10: cont'd/4

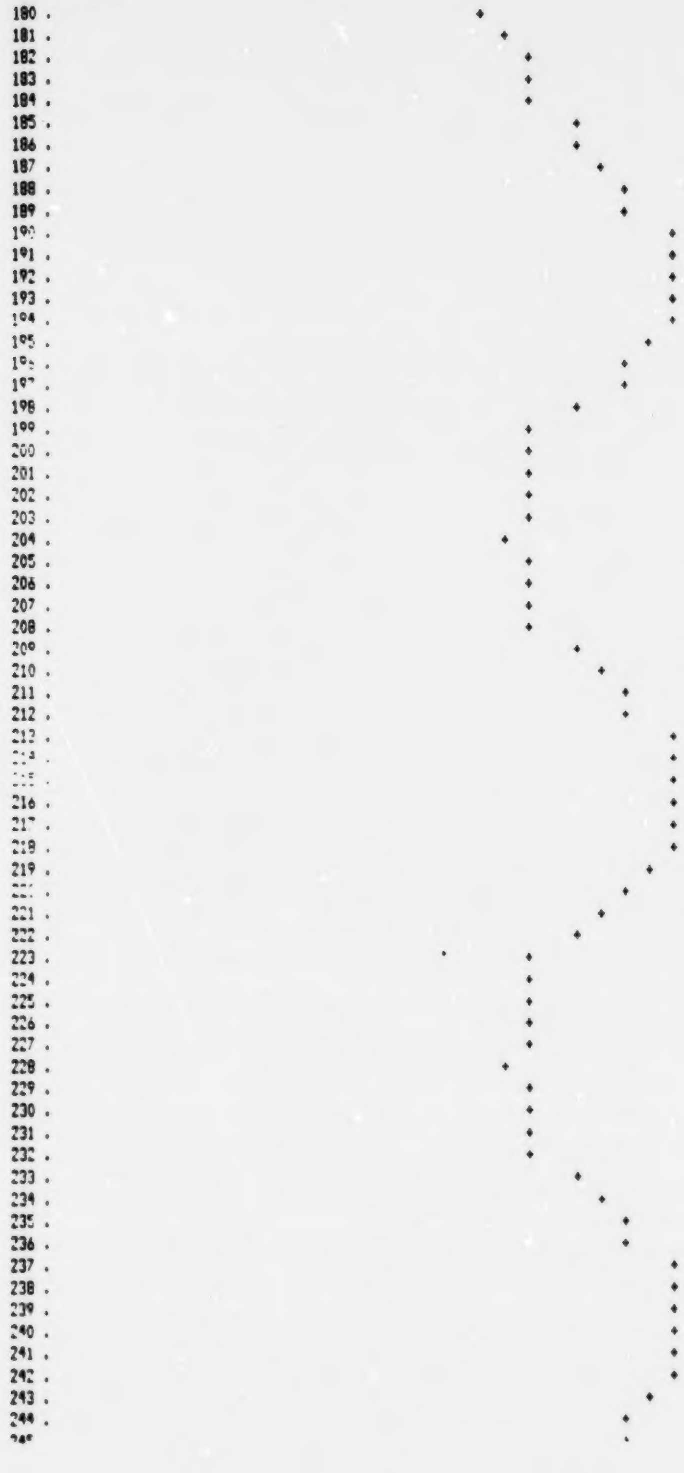

Figure E.10: cont'd/5

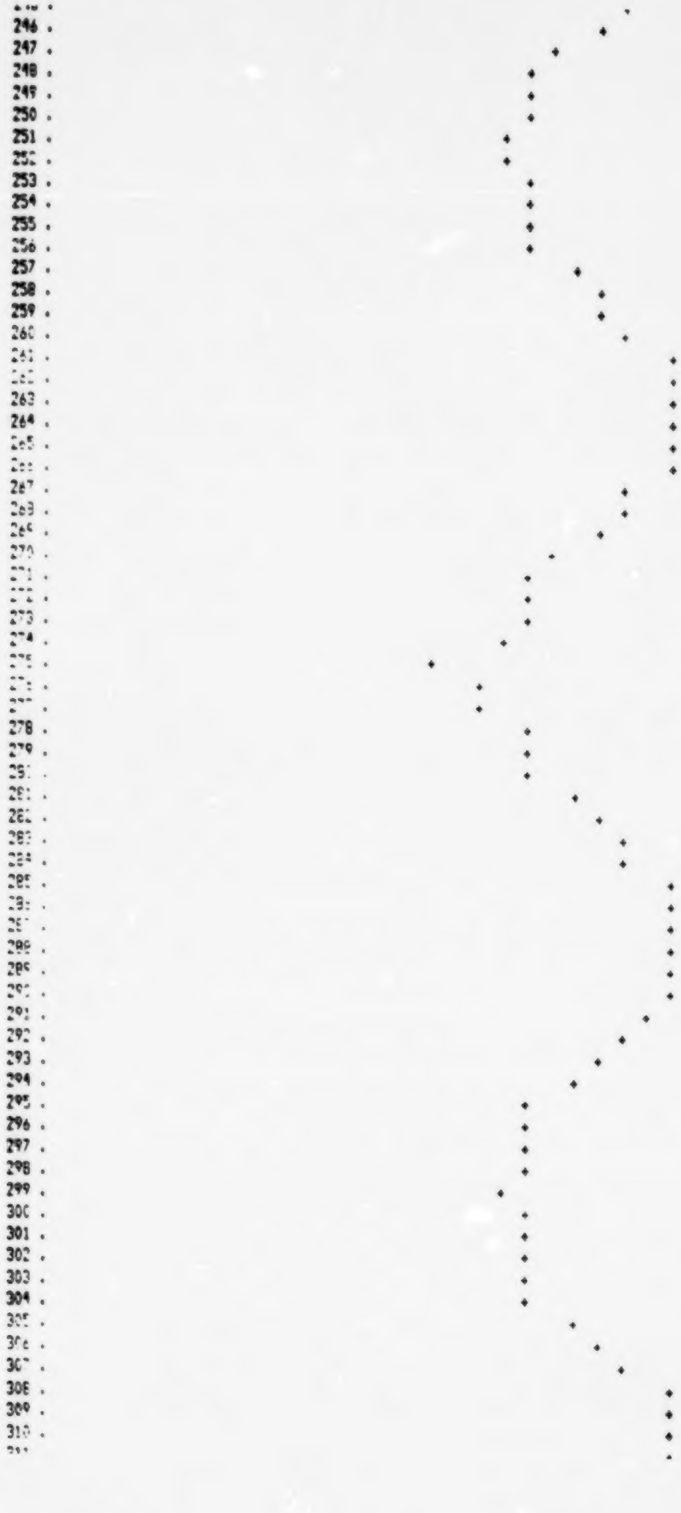

Figure E.10: cont'd/6

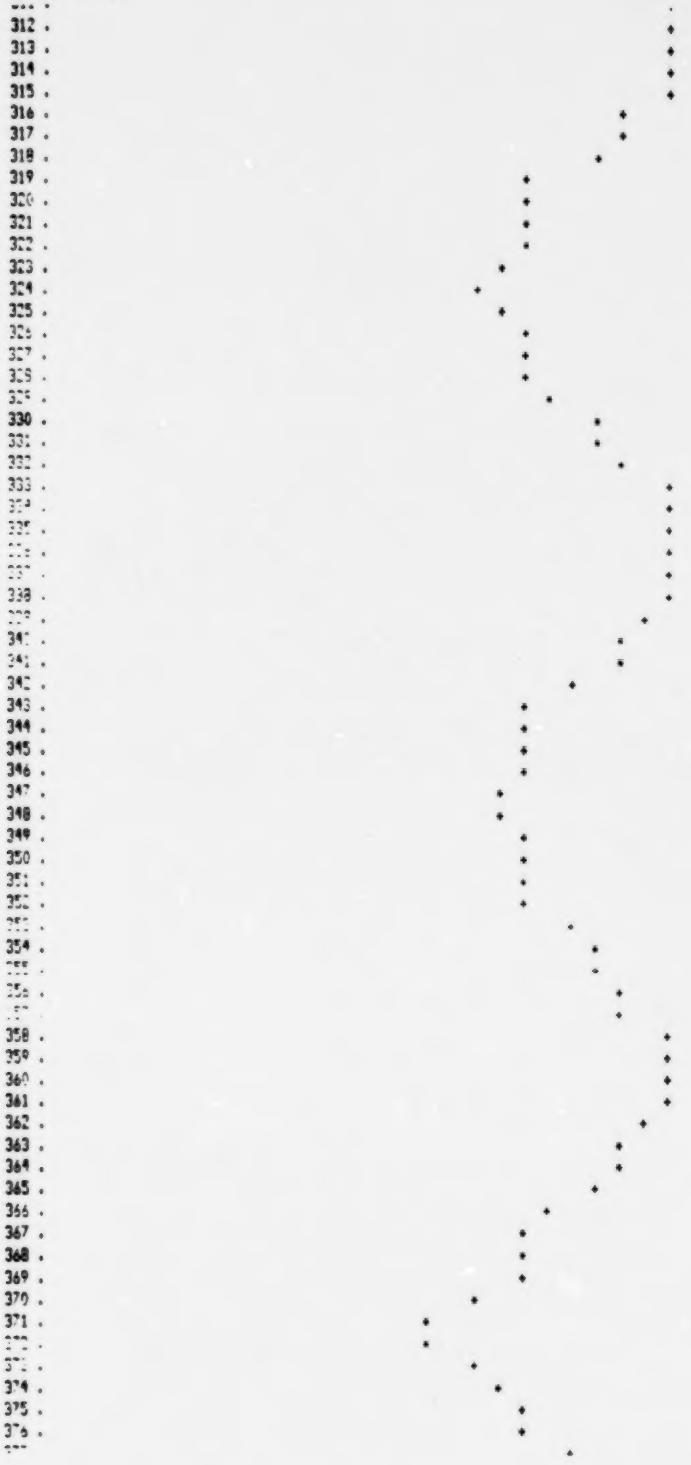

**Figure E.10:** cont'd/7

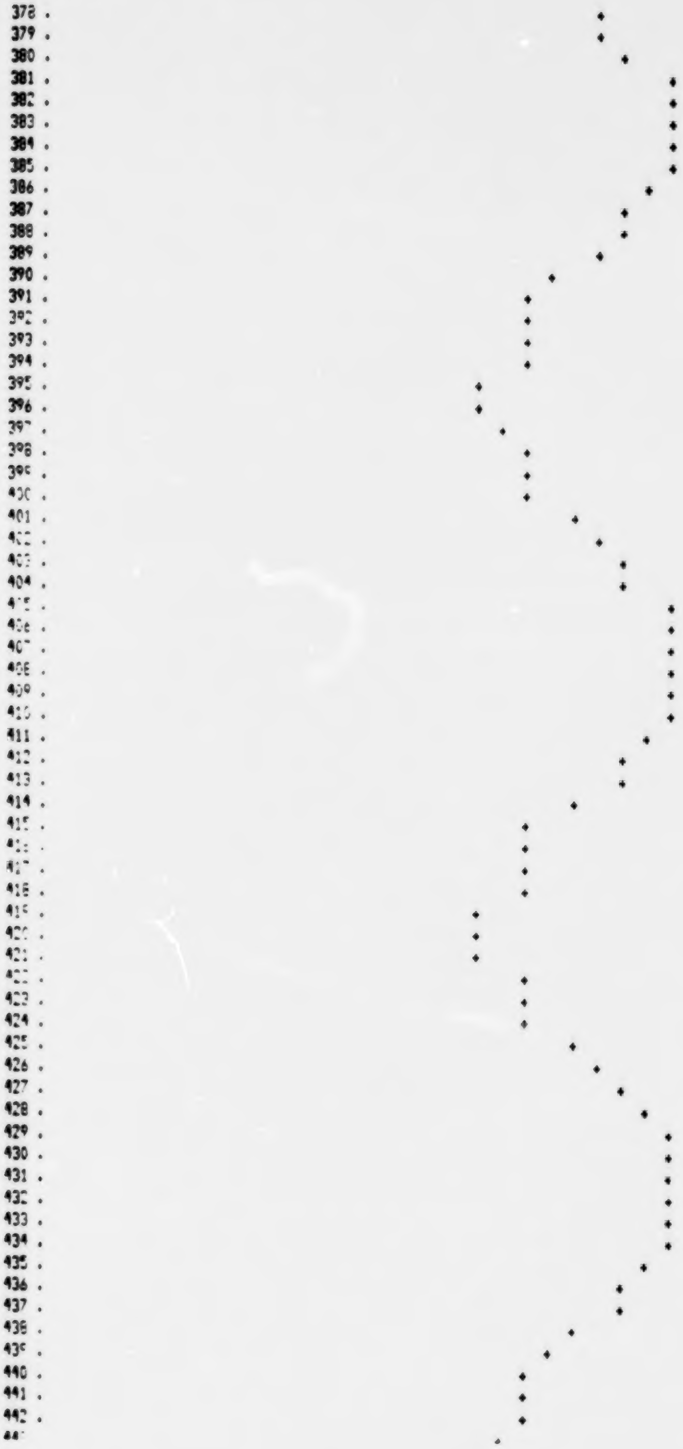

Figure E.10: cont'd/8

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491 .                   *
492 .                   *
493 .                    *
494 .                    *
495 .                    *
496 .                    *
497 .                      *
498 .                       *
499 .                        *
500 .                        *
501 .                          *
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507 .                         *
508 .                        *
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**Figure E.10:** cont'd/9

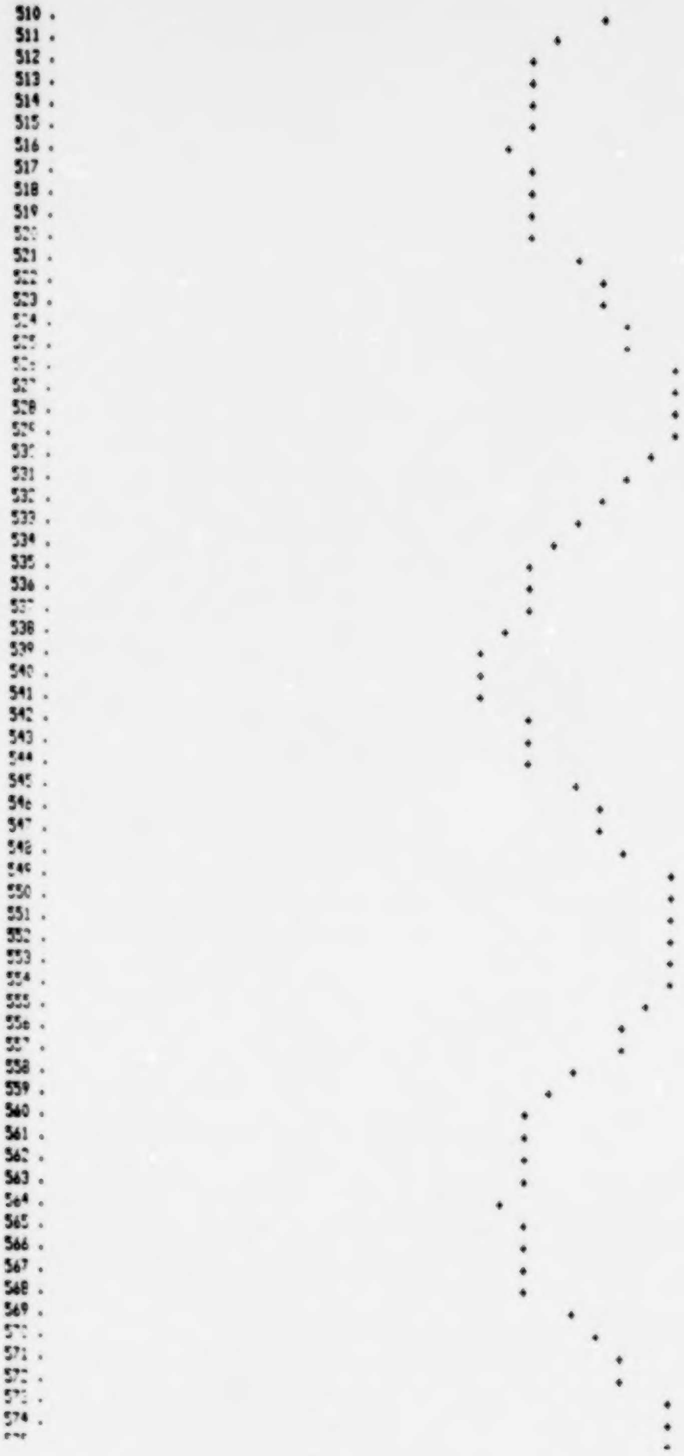

Figure E.10: cont'd/ 10

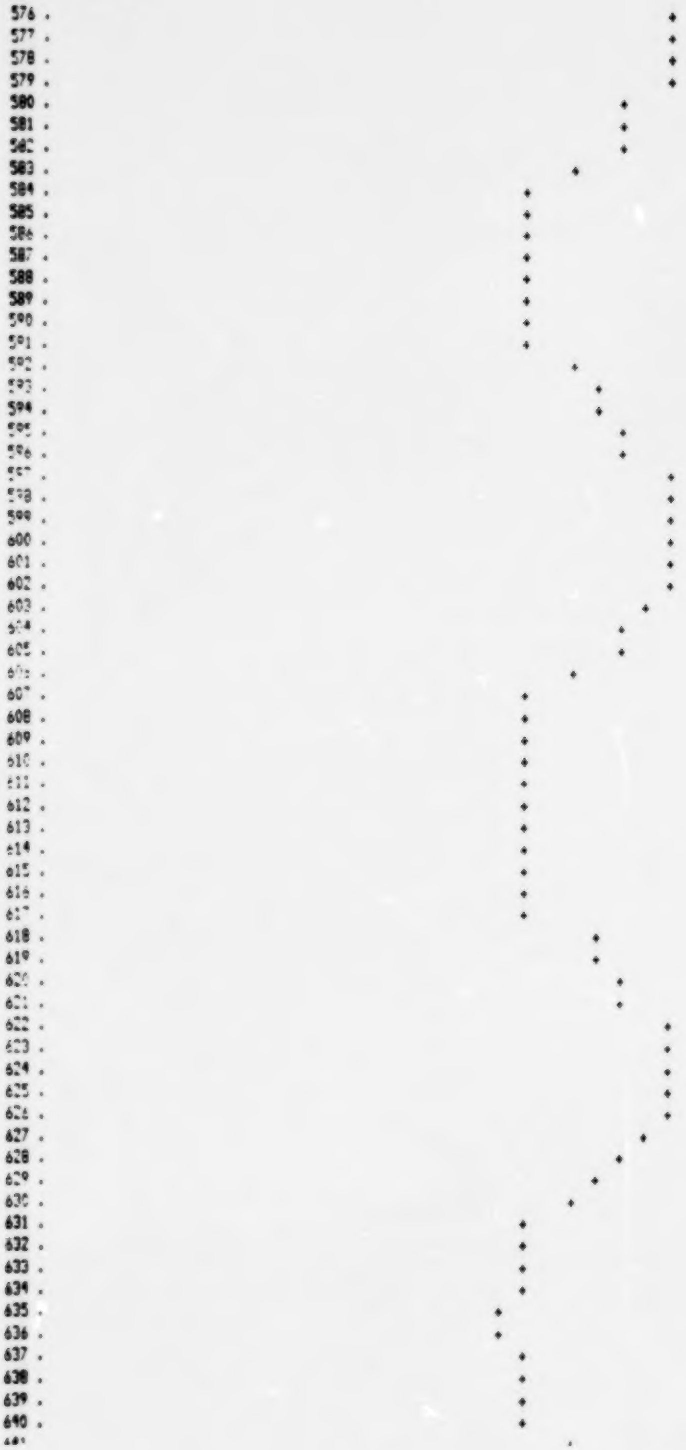

Figure E.10: cont'd/11

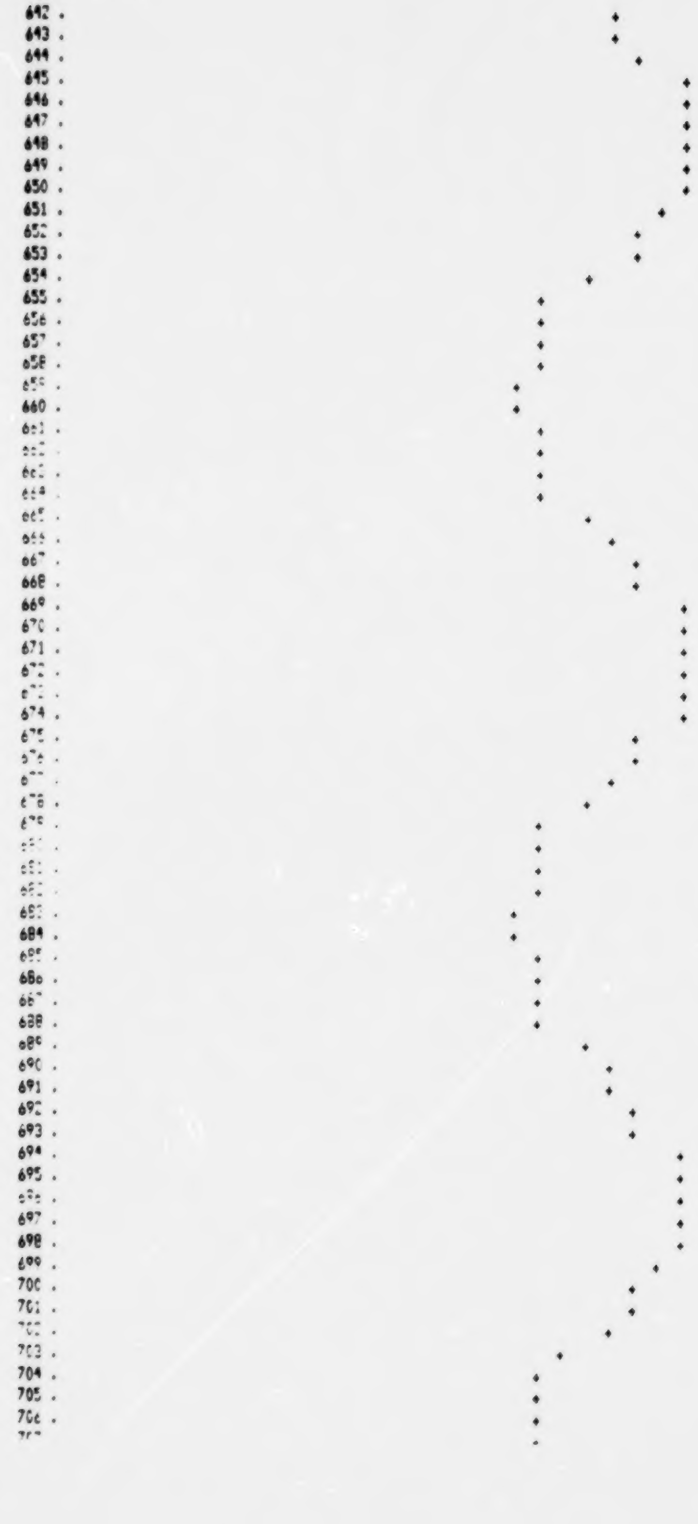

Figure E.10: cont'd/12

```
708 .
709 .                   +
710 .                   +
711 .                   +
712 .                    +
713 .                     +
714 .                      +
715 .                       +
716 .                       +
717 .                         +
718 .                         +
719 .                         +
720 .                         +
```

Figure E.11: Plot of Stability/Wind Speed vs Time from Release (Hours) 720 Hr. Duration, 5 Years Data
Elevated (50 m) Release, St. John Airport Met. Data 5 km Downwind Receptor

```
stability class/ wind speed and # of occurances

 61  51  62  52  41  63  53  42  31  64  54  43  32  21  65  55  44  33  22  11  45  34  23  12  35  24  13  25  14  15
  6   0 103  62  79  58  56  78  28   0  39 208   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

pattern analysis at 25.0 %
```

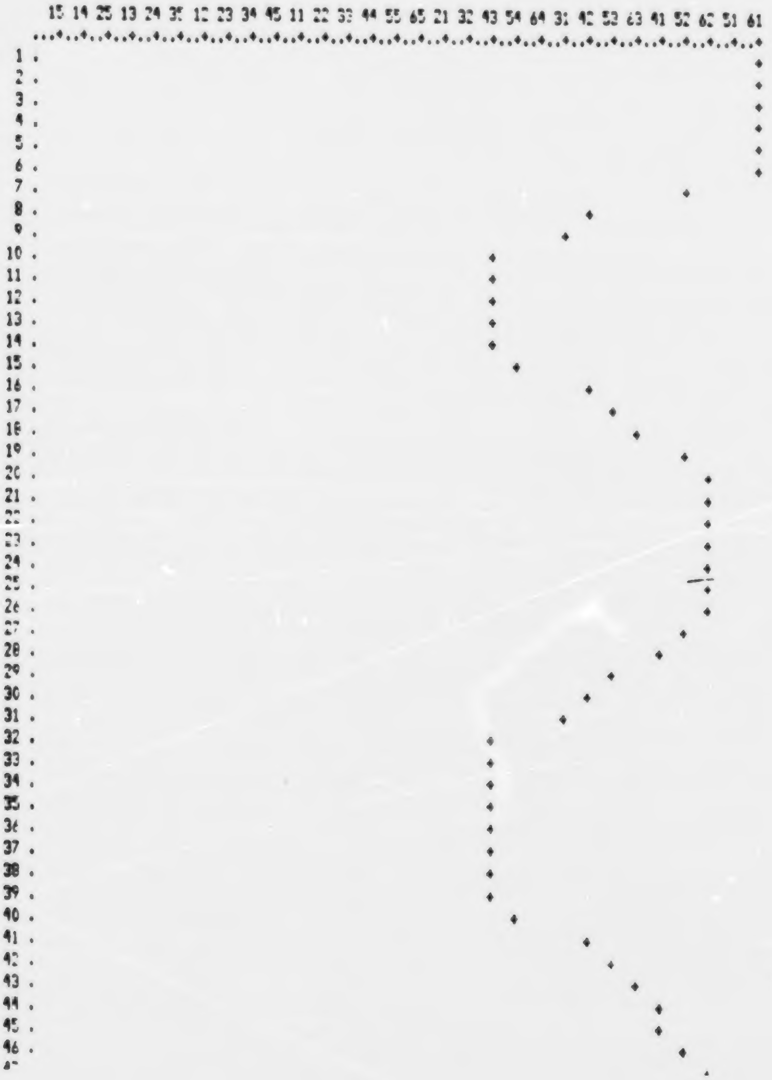

Figure E.11: cont'd/2

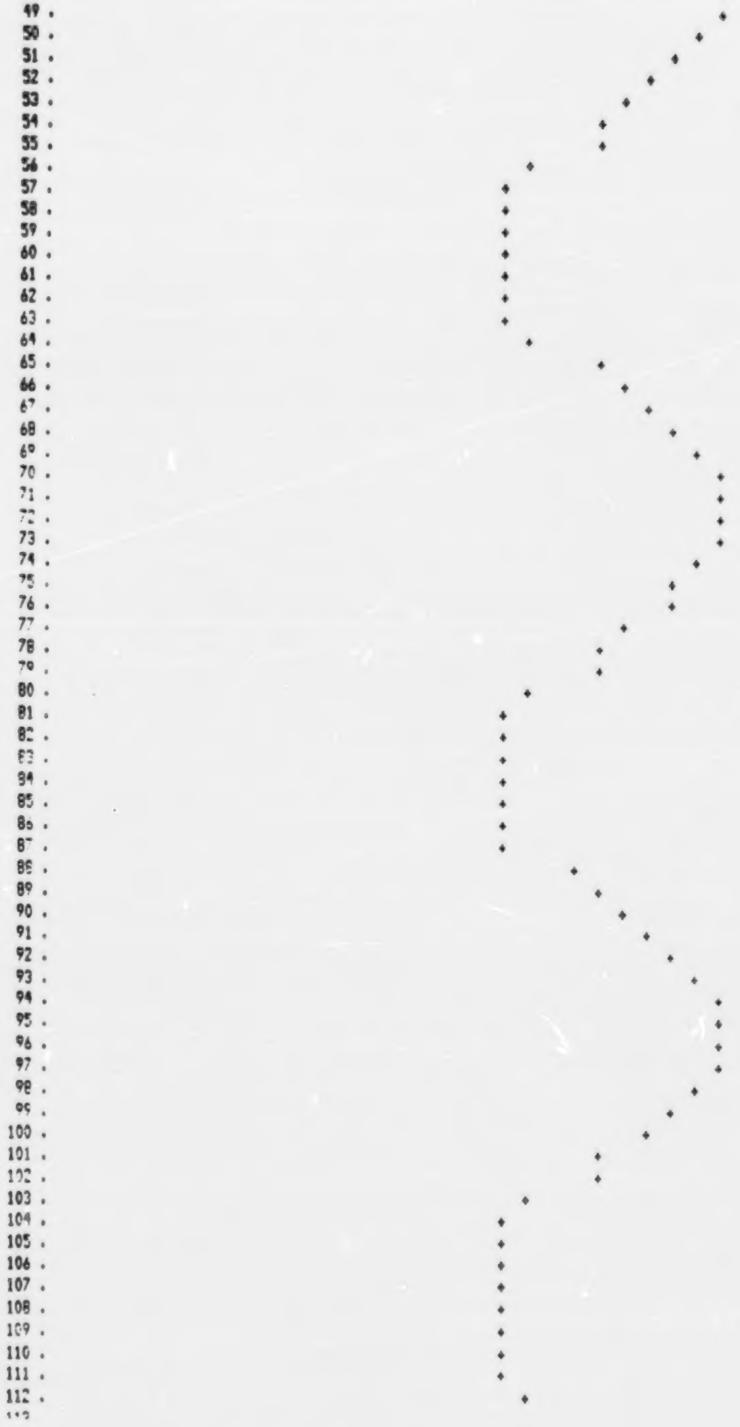

Figure E.11: cont'd/3

Figure E.11: cont'd/4

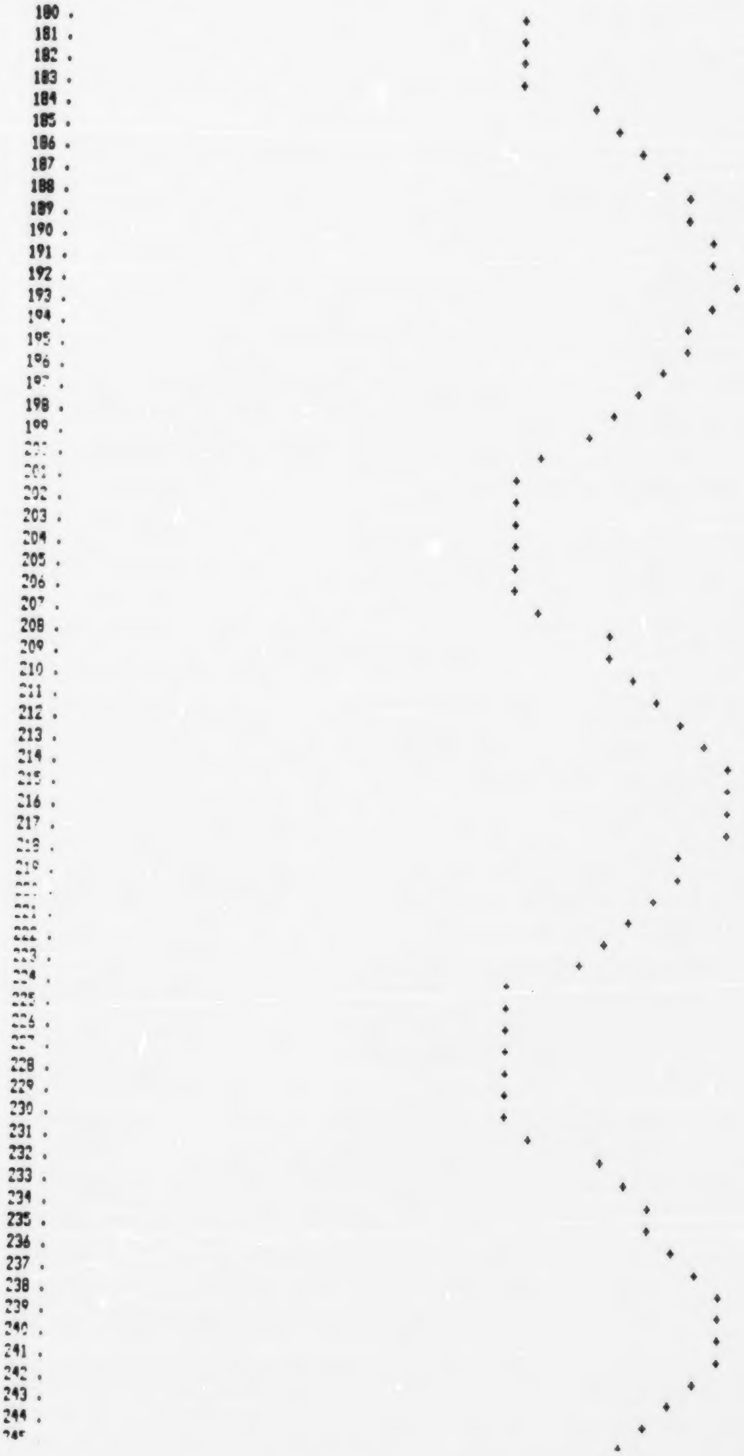

**Figure E.11:** cont'd/5

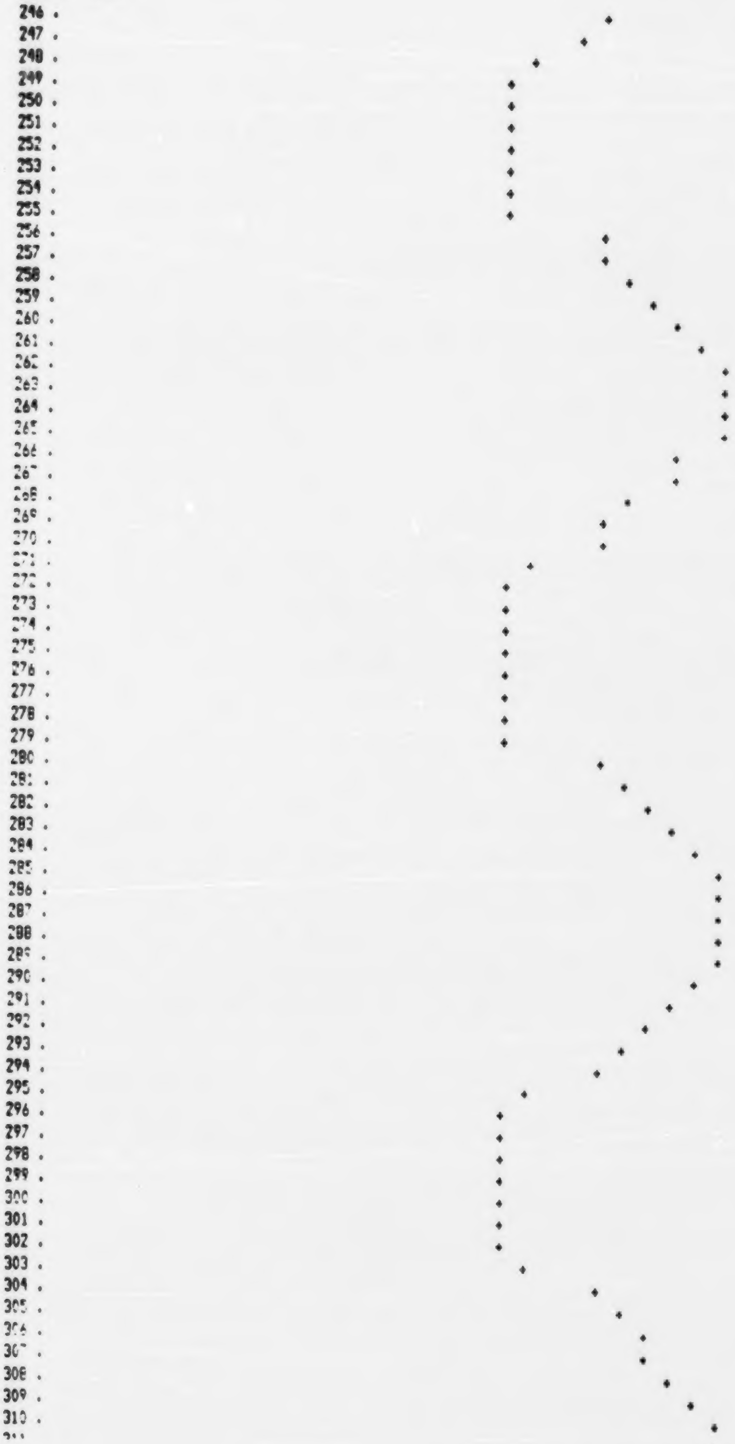

**Figure E.11:** cont'd/6

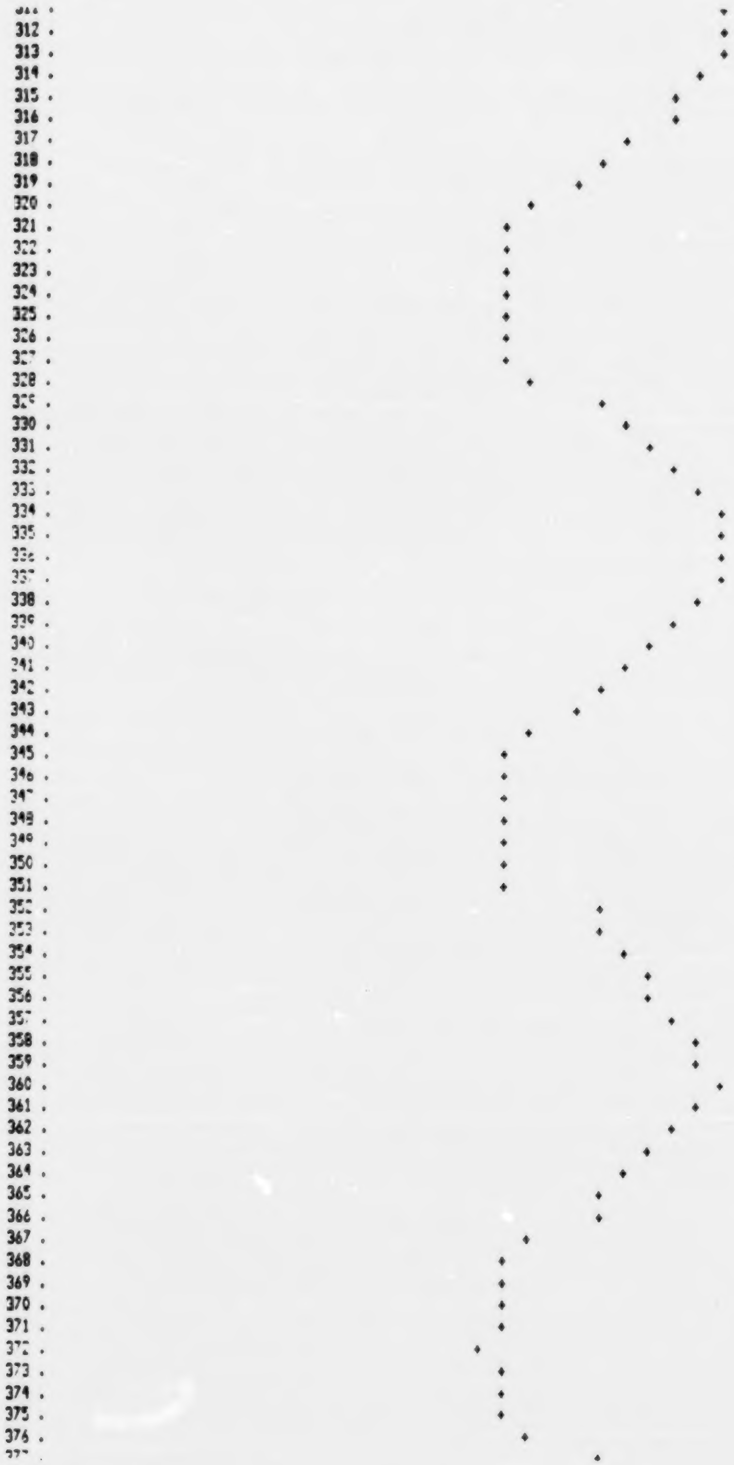

**Figure E.11:** cont'd/ 7

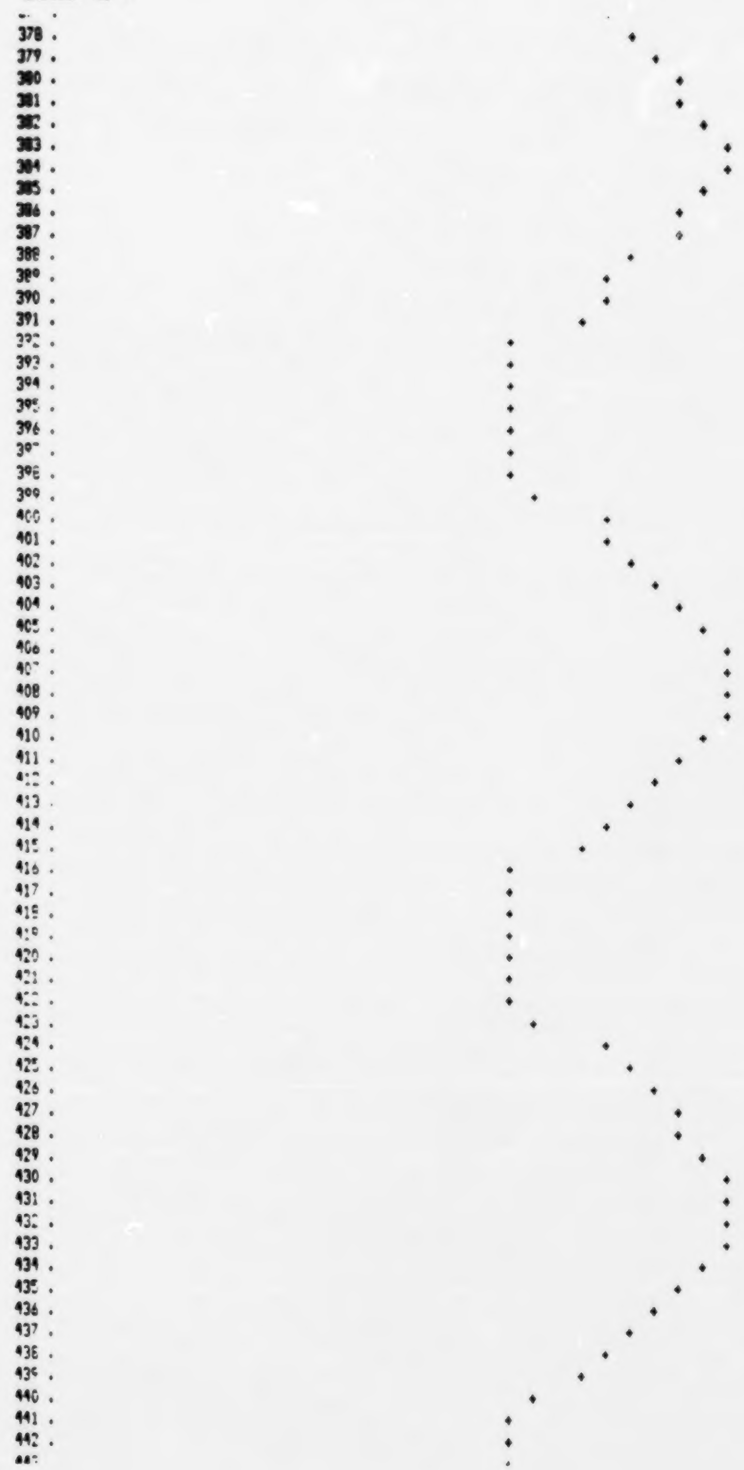

Figure E.11: cont'd/8

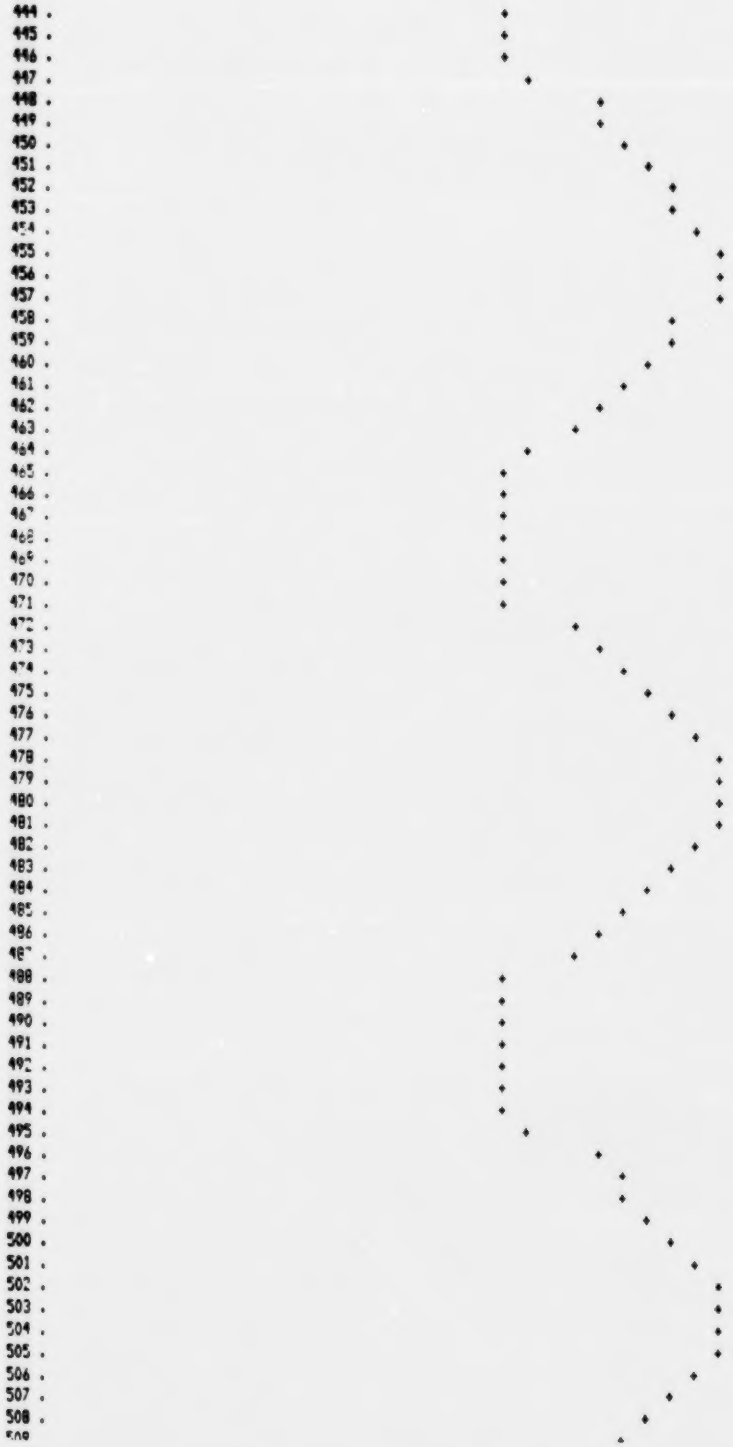

**Figure E.11:** cont'd/9

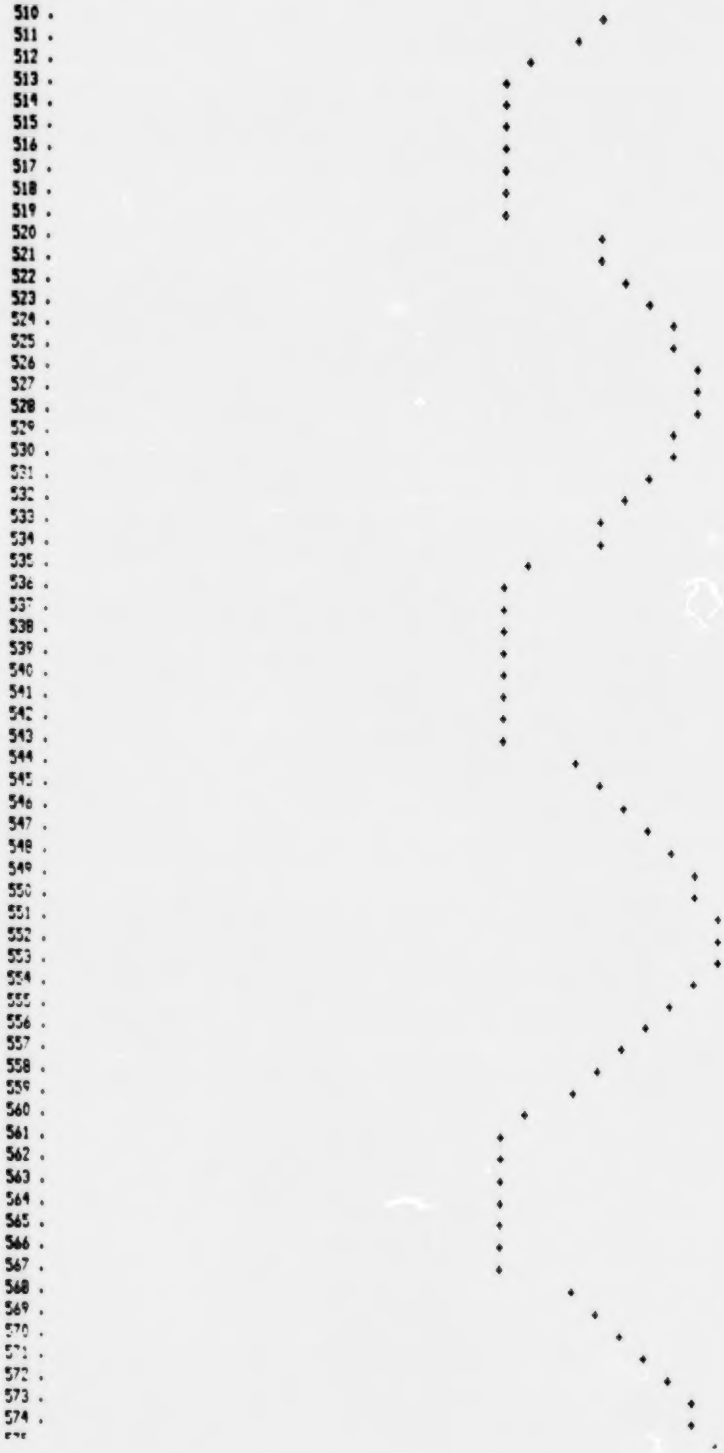

Figure E.11: cont'd/10

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Figure E.11: cont'd/11

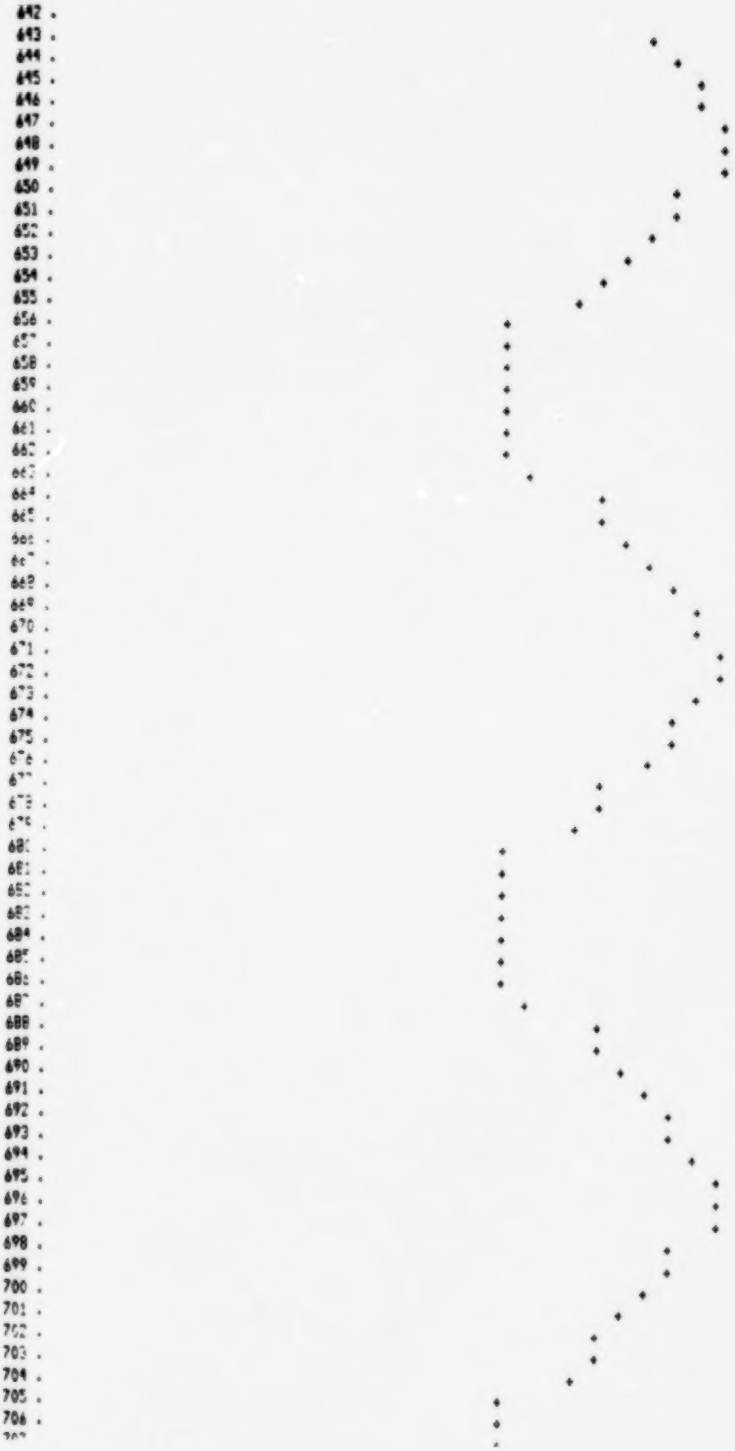
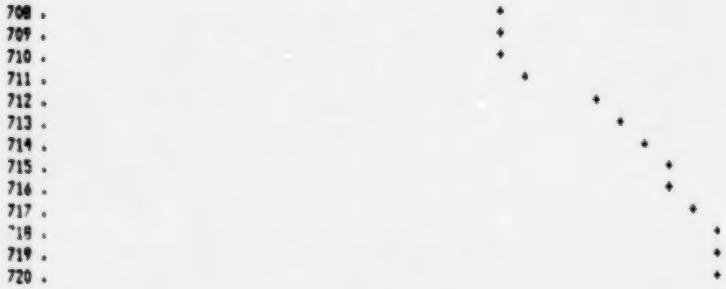


Figure E.11: cont'd/ 12



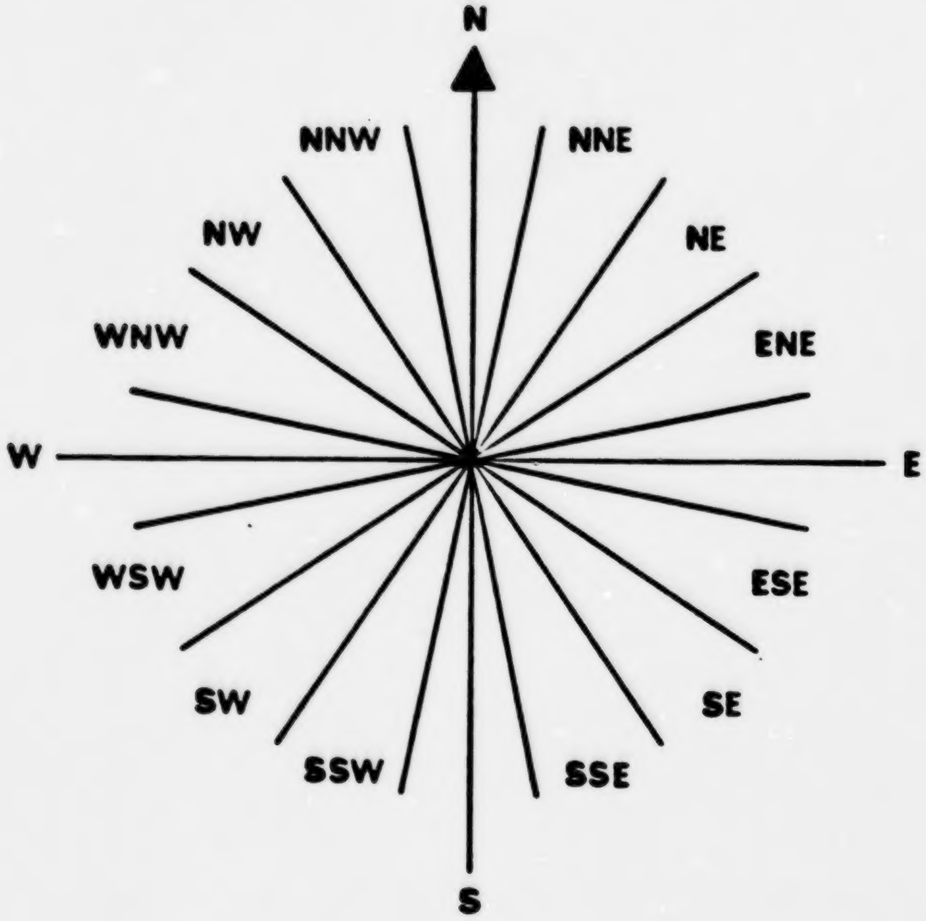

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Figure E.12: Wind Direction Diagram - 22.5° in each sector

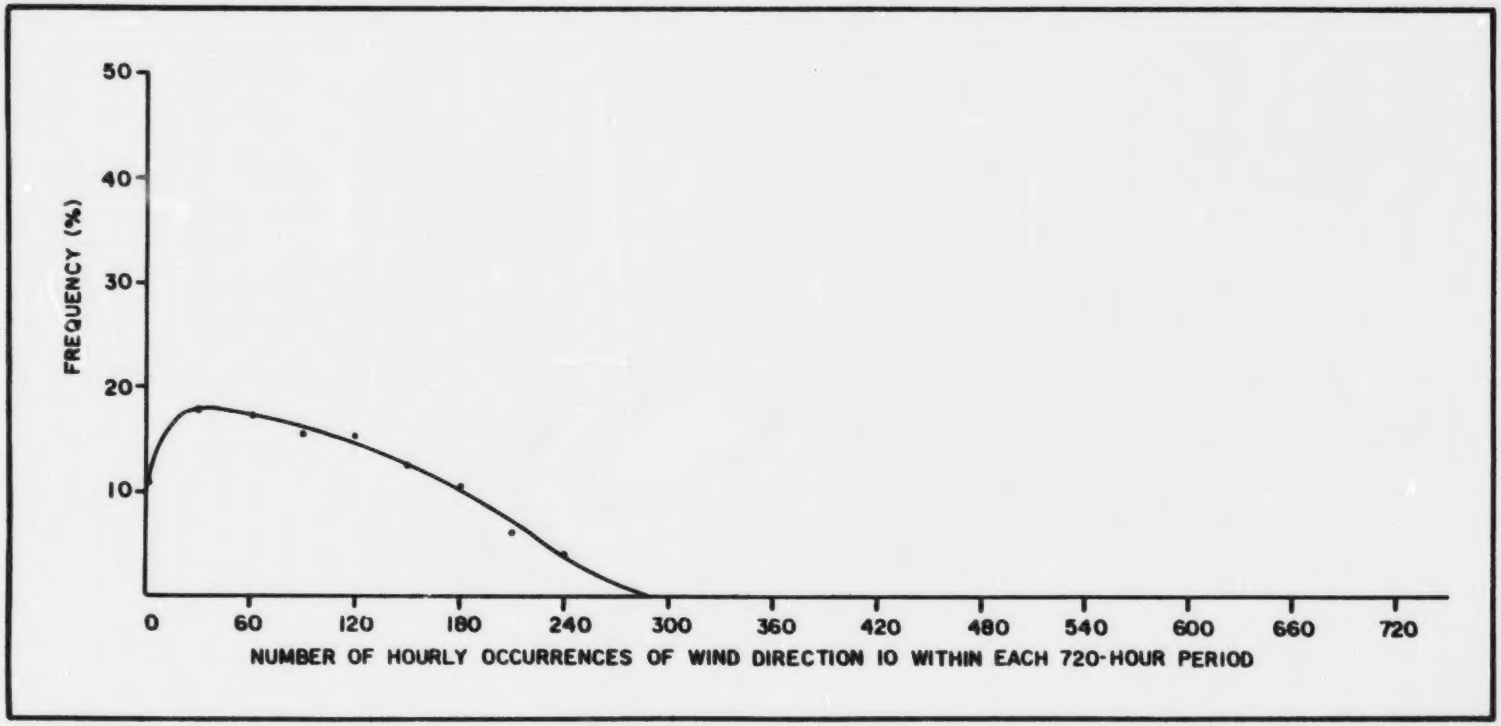


Figure E.13a: Frequency distribution for the number of hourly occurrences of wind direction 10 during each of the ~42,000 720-hour scenarios (5 year data, St. John Airport).

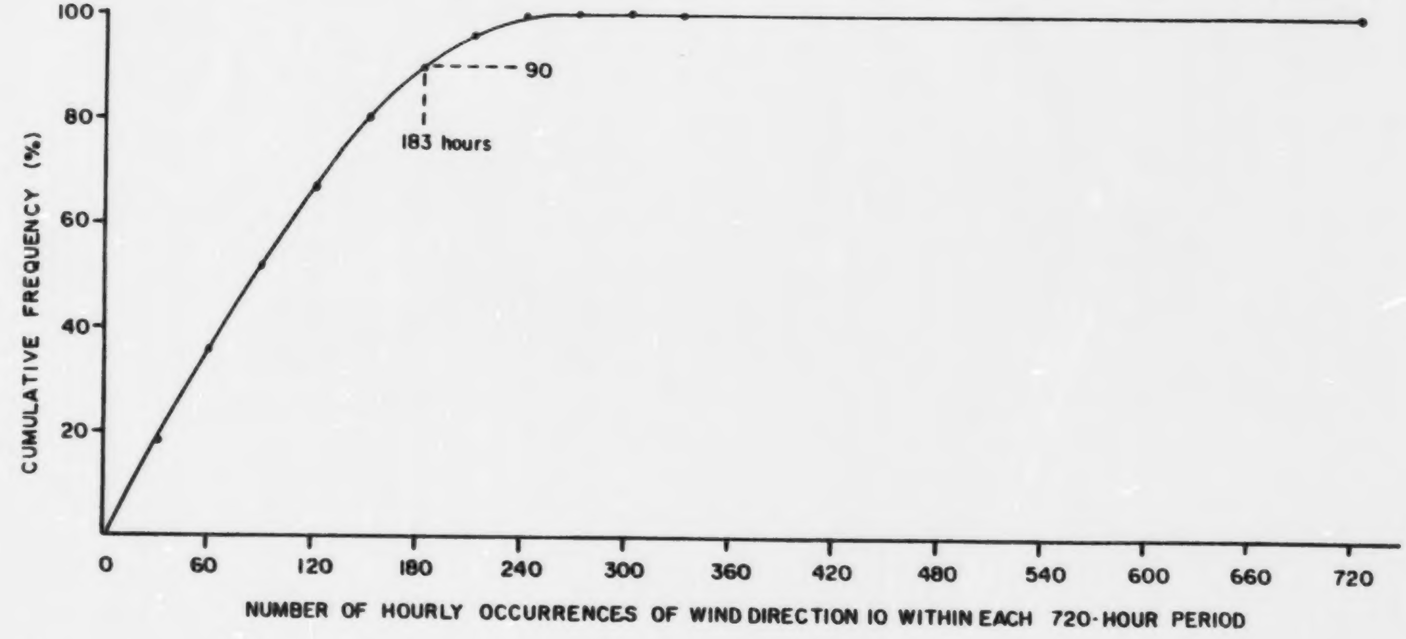


Figure E.13b: Cumulative frequency distribution for the number of hourly occurrences of wind direction 10 during each of the ~42,000 720-hour scenarios (5 year data, St. John Airport).

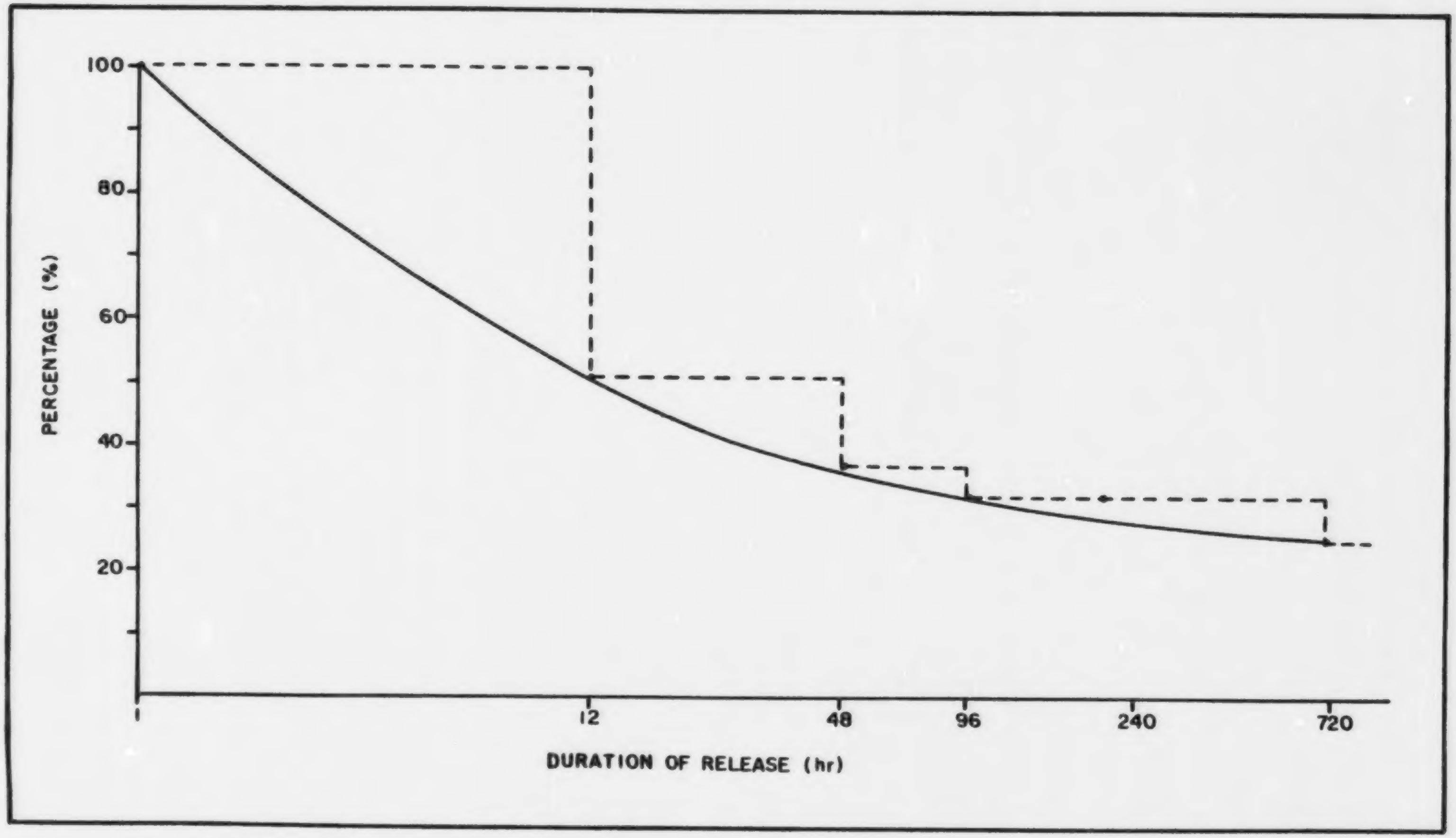


Figure E.14: Maximum percentage of occurrence of wind in the same direction that will not be exceeded in more than 10% of the ~42,000 scenarios (5 year data, St. John Airport).

## F. WEATHER SCENARIOS FOR THE THREE SELECTED SITES

The summary weather scenarios for St. John, Quebec and Trenton Airports for ground-level releases and elevated releases for receptors at 1 km, 3 km and 5 km are presented in Tables F.1 - F.12.

One notable feature of these scenarios for the three sites is that they do not significantly differ from each other from site to site, especially in terms of trends, considering that they have been based on data from widely differing meteorological regions in Canada. This could be viewed as an advantage of the methodology developed in the present study in that it is rather robust with respect to regional differences, and that we can have reasonable confidence in using for various regions a single scenario based on a conservative envelope of these three scenarios. Of course, use of such a scenario is recommended only when no meteorological information is available for a region, or for a preliminary analysis before a full hour-by-hour analysis can be done using representative station data. Description of how a full analysis can be done when hourly data are available from on-site programs or representative stations, is beyond the scope of the present project.

In the scenarios, the atmospheric conditions are not allowed to change within the first several hours, in accordance with the probability of re-occurrence of the start condition determined through the pattern analysis method described in Chapter E (see Figure E.8 for example for a ground-level release). Subsequent hours up to 12 hours see changing conditions. For times larger than 12 hours, average conditions for each interval of interest are specified as discussed in Chapter E.3, for the purposes of practicality. Note that the 0th hour is the hour that starts at the beginning of the release and continues until 59 minutes, the 1st hour starts at 60 minutes and continues until 119 minutes, etc.

For ground-level releases that last beyond the first hour, plume meander should be credited during Pasquill stability classes D, E, and F ($i = 4,5,$ and 6), based on the justifications given by Snell and Jubach (1981) and the practice adopted in U.S. NRC Reg. Guide 1.145 (1983). However, since plume meander is not included in the dispersion parameters within the framework of N288.2, effect of plume meander was also not considered in the original ranking of weather conditions (Table E.1). It is relatively easy to include meandering effects in the pattern analysis method if this is done through the dispersion parameters, but it is more difficult to include them using the framework of N288.2. Simultaneous use of the dispersion parameters corrected for meandering, with the N288.2 framework, i.e., with the sector average equation for longer (than 1 hr) term releases, is incompatible. Hence use of the corrected dispersion parameters requires use of the short-term equation repeatedly for longer term releases, for which, in turn, high-resolution (e.g., to within 10° as opposed to 22.5°) wind direction data are desirable in the pattern analysis. To this end, the scenarios given here are intended for use within the N288.2 framework and not with corrected (for meandering) dispersion parameters. The effect of taking meandering and sector averaging into account throughout the pattern analysis needs to be further investigated.

The stability-wind speed scenarios for release durations greater than 30 days are based on the consistently repetitive stability-wind speed patterns within the interval between 25 hours and 30 days. For wind direction, the percentage corresponding to 30 days (720 hours) in Figure E.14 and corresponding figures for other sites are used in the scenarios. Note again that, using the 30-day value for time periods larger than 30 days will yield conservative scenarios based on the discussion in Chapter E.2.2.

TABLE F.1: Weather Scenario for Ground Level Release, St. John Airport

| Time after beginning of accident | Atmospheric conditions |
|---|---|
| 0 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100m; wind direction toward the nearest point on the boundary, steady wind direction; |
| 1 - 6 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m; wind direction toward the nearest point on the boundary, sector average; |
| 7 h | As above, except wind speed 1 m/s; |
| 8 h | Pasquill D, wind speed 0.5 m/s, mixing layer height 600 m, wind direction toward the nearest point on boundary; |
| 9 h | Pasquill C, wind speed 0.5 m/s, mixing layer height 600 m, wind direction toward the nearest point on boundary; |
| 10 h | Pasquill D, wind speed 1 m/s, mixing layer height 600 m, wind direction toward the nearest point on boundary; |
| 11 h | Pasquill B, wind speed 0.5 m/s, mixing layer height 600 m, wind direction toward the nearest point on boundary; |
| 12 h | Pasquill C, wind speed 1 m/s, mixing layer height 600 m, wind direction as above; |
| 13 h - 24 | 25% Pasquill D, wind speed 2 m/s, mixing layer height 600 m; 75% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; wind direction 51% frequency toward the nearest point on boundary; |
| 25 h - 2 d | Pasquill D, wind speed 0.5 m/s, mixing layer height 600 m; wind direction 51% frequency toward the nearest point on boundary; |
| 3 - 4 d | As above, but wind direction 37% frequency toward the nearest point on boundary; |
| 5 - 30 d | As above, but wind direction 32% frequency toward the nearest point on boundary; |
| > 30 d | As above, but wind direction 25% frequency toward the nearest point on boundary; |

TABLE F.2: Weather Scenario for Elevated Release, Downwind Distance: 1 km, St. John Airport

| Time after beginning of accident | Atmospheric conditions |
|---|---|
| 0 h | Pasquill D; wind direction 0.5 m/s, mixing layer height 600 m; wind direction toward the receptor at 1 km; |
| 1 - 3 h | Pasquill D; wind speed 0.5 m/s, mixing height 600 m; sector average; |
| 4 h | As above, except Pasquill C |
| 5 - 7 h | As above, except wind speed 1 m/s |
| 8 h | Pasquill C, wind speed 1 m/s, wind direction and mixing layer height as above; |
| 9 h | Pasquill D; wind speed 1 m/s, wind direction and mixing layer height as above; |
| 10 - 12 h | Pasquill D, wind speed 2 m/s, mixing layer height and wind direction as above; |
| 13 - 24 h | Pasquill D, wind speed 2 m/s, mixing layer height 600 m, wind direction 51% frequency towards the receptor at 1 km. |
| 25 h - 2 d | 20% Pasquill B, wind speed 1 m/s, 80% Pasquill D, wind speed 2 m/s, mixing layer height 600 m, wind direction 51% frequency towards the receptor at 1 km. |
| 3 - 4 d | 20% Pasquill E, wind speed 2 m/s, mixing layer height 100 m; 80% Pasquill C, wind speed 2 m/s; mixing layer height 600 m, wind direction 37% frequency toward the receptor at 1 km; |
| 5 - 30 d | As above except wind direction 32% frequency toward receptor at 1 km; |
| >30 d | As above except wind direction 25% toward receptor at 1 km; |

TABLE F.3: Weather Scenario for Elevated Release, Downwind Distance: 3 km, St. John Airport

| Time after beginning of accident | Atmospheric conditions |
|---|---|
| 0 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m, wind direction toward the receptor at 3 km; |
| 1 - 5 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m, sector average; |
| 6 h | As above, except Pasquill D and mixing layer height of 600 m; |
| 7 h | As above, except wind speed 1 m/s; |
| 8 h | Pasquill D, wind speed 1 m/s, mixing layer height of 600 m, wind direction as above; |
| 9 h | Pasquill F wind speed 2 m/s, mixing layer height 100 m, wind direction as above; |
| 10 - 12 h | Pasquill D, wind speed 2 m/s mixing layer height 600 m, wind direction as above; |
| 13 - 24 h | 25% Pasquill D, wind speed 2 m/s, mixing layer height 600 m; 75% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; wind direction 51% frequency toward receptor at 3 km; |
| 25 h - 2 d | 40% Pasquill F, wind speed 2 m/s, mixing layer height 100 m; 60% Pasquill D, wind speed 2m/s, mixing layer height 600 m; wind direction 51% frequency toward receptor at 3 km; |
| 3 d - 4 d | As above except wind direction 37% frequency toward receptor at 3 km; |
| 5 d - 30 d | As above except wind direction 32% frequency toward receptor at 3 km; |
| > 30 d | As above except wind direction 25% frequency toward receptor at 3 km. |

TABLE F.4: Weather Scenario for Elevated Release, Downwind Distance: 5 km, St. John Airport

| Time after beginning of accident | Atmospheric conditions |
|---|---|
| 0 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m, wind direction toward receptor at 5 km; |
| 1 - 6 h | Pasquill F, wind speed 0.5 m/s, mixng layer height 100 m, sector average; |
| 7 h | Pasquill E, wind speed 1 m/s, mixing layer height 100 m, wind direction as above |
| 8 h | Pasquill D, wind speed .5 m/s, mixing layer height 600 m wind direction as above |
| 9 h | Pasquill C, wind speed .5 m/s, mixing layer height 600 m wind direction as above |
| 10 - 12 h | Pasquill D, wind speed 2 m/s, mixing layer height 600 m, wind direction as above |
| 13 - 24 h | 50% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; 50% Pasquill D, wind speed 2 m/s, mixing layer height 600 m; wind direction 51% frequency toward receptor at 5 km; |
| 25 h - 2 d | 25% Pasquil D, wind speed 2 m/s, mixing layer height 600 m; 75% Pasquill D, wind speed 0.5 m/s; mixing layer height 600 m, wind direction 51% frequency toward receptor at 5 km; |
| 3 d - 4 d | 25% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; 75% Pasquill D, wind speed 2 m/s, mixing layer height 600 m; wind direction 37% frequency toward receptor at 5 km; |
| 5 d - 30 d | As above, except wind direction 32% frequency toward receptor at 5 km; |
| > 30 d | As above except wind direction 25% frequency toward receptor at 5 km. |

TABLE F.5: Weather Scenario for Ground Level Release, Quebec Airport

| Time after beginning of accident | Atmospheric conditions |
|---|---|
| 0 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100m; wind direction toward the nearest point on the boundary, steady wind direction; |
| 1 - 3 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m; wind direction toward the nearest point on the boundary, sector average; |
| 4 - 6 h | As above except wind speed 1 m/s; |
| 7 h | Pasquill E, wind speed 1 m/s, mixing layer height 100 m, wind direction as above; |
| 8 h | Pasquill D, wind speed 0.5 m/s, mixing layer height 600 m, wind direction as above; |
| 9 h | Pasquill C, wind speed 0.5 m/s, mixing layer height 600 m, wind direction as above; |
| 10 - 12 h | Pasquill D, wind speed 1 m/s, mixing layer height 600 m, wind direction as above |
| 13 - 24 h | 40% Pasquill D, wind speed 1 m/s, mixing layer height 600 m; 60% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; wind direction 58% frequency toward the nearest point on boundary; |
| 25 h - 2 d | Pasquill F, wind speed 2 m/s, mixing layer height 100 m, wind direction 58% frequency toward the nearest point on boundary; |
| 3 - 4 d | 35% Pasquill D, wind speed 1 m/s mixing layer height 600 m; 65% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; wind direction 43% frequency toward the nearest point on boundary; |
| 5 - 10 d | As above except wind direction 36% frequency toward the nearest point on boundary; |
| 11 - 30 d | As above except wind direction 31% frequency toward the nearest point on boundary; |
| > 30 d | As above except wind direction 28% frequency toward the nearest point on boundary; |

TABLE F.6: Weather Scenario for Elevated Release, Downwind Distance: 1 km, Quebec Airport

| Time after beginning of accident | Atmospheric conditions |
|---|---|
| 0 h | Pasquill D; wind direction 0.5 m/s, mixing layer height 600 m; wind direction toward the receptor at 1 km; |
| 1 - 4 h | Pasquill D; wind speed 0.5 m/s, mixing height 600 m; sector average; |
| 5 h | As above except Pasquill C; |
| 6 - 12 h | Pasquill D, wind speed 1 m/s, mixing layer height 600 m, wind direction as above; |
| 13 - 24 h | 15% Pasquill D, wind speed 2 m/s, mixing layer height 600 m; 85% Pasquill E, wind speed 1 m/s, mixing layer height 100 m; wind direction 58% frequency toward receptor at 1 km; |
| 25 h - 2 d | Pasquill D, wind speed 2 m/s, mixing layer height 600 m, wind direction 58% frequency toward receptor at 1 km; |
| 3 - 4 d | 20% Pasquill B, wind speed 1 m/s; 80% Pasquill D, wind speed 2 m/s; mixing layer height 600 m, wind direction 43% frequency toward receptor at 1 km; |
| 5 - 10 d | As above except wind direction 36% frequency toward receptor at 1 km; |
| 11 - 30 d | As above except wind direction 31% frequency toward receptor at 1 km; |
| > 30 d | As above except wind direction 28% frequency toward receptor at 1 km. |

TABLE F.7: Weather Scenario for Elevated Release, Downwind Distance: 3 km, Quebec Airport

| Time after beginning of accident | Atmospheric conditions |
|---|---|
| 0 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m, wind direction toward the receptor at 3 km; |
| 1 - 2 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m, sector average; |
| 3 h | As above except Pasquill D, mixing layer height 600 m; |
| 4 h | Pasquill E, wind speed 1 m/s, mixing layer height 100 m, wind direction as above; |
| 5 - 6 h | Pasquill F, wind speed 1 m/s, mixing layer height 100 m, wind direction as above; |
| 7 h | Pasquill C, wind speed 0.5 m/s, mixing layer height 600 m, wind direction as above; |
| 8 - 9 h | Pasquill D, wind speed 1 m/s, mixing layer height 600 m, wind direction as above; |
| 10 - 12 h | Pasquill C, wind speed 1 m/s, mixing layer height 600 m, wind direction as above; |
| 13 - 24 h | Pasquill D, wind speed 1 m/s, mixing layer height 600 m, wind direction 58% frequency toward receptor at 3 km; |
| 25 h - 2 d | 40% Pasquill D, wind speed 2 m/s, mixing layer height 600 m; 60% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; wind direction 58% frequency toward receptor at 3 km; |
| 3 - 4 d | 45% Pasquill D, wind speed 2 m/s, mixing layer height 600 m; 55% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; wind direction 43% frequency toward receptor at 3 km; |
| 5 - 10 d | As above except wind direction 36% frequency toward receptor at 3 km; |
| 11 - 30 d | As above except wind direction 31% frequency toward receptor at 3 km; |
| > 30 d | As above except wind direction 28 % frequency toward receptor at 3 km. |

TABLE F.8: Weather Scenario for Elevated Release, Downwind Distance: 5 km, Quebec Airport

| Time after beginning of accident | Atmospheric conditions |
|---|---|
| 0 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m, wind direction toward receptor at 5 km; |
| 1 - 3 h | Pasquill F, wind speed 0.5 m/s, mixng layer height 100 m, sector average; |
| 4 - 6 h | As above except wind speed 1 m/s; |
| 7 h | Pasquill D, wind speed 0.5 m/s, mixing layer height 600 m, wind direction as above; |
| 8 - 9 h | Pasquill D, wind speed 1 m/s, mixing layer height 600 m, wind direction as above; |
| 10 h | Pasquill C, wind speed 0.5 m/s, mixing layer height 600 m, wind direction as above; |
| 11 - 12 h | Pasquill D, wind speed 2 m/s, mixing layer height 600 m, wind direction as above; |
| 13 - 24 h | Pasquill D, wind speed 0.5 m/s, mixing layer height 600 m, wind direction 58% frequency toward receptor at 5 km; |
| 25 h - 2 d | 45% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; 55% Pasquill D, wind speed 2 m/s, mixing layer height 600 m; wind direction 58% frequency toward receptor at 5 km; |
| 3 - 4 d | 40% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; 60% Pasquill D, wind speed 2 m/s, mixing layer height 600 m, wind direction 43% frequency toward receptor at 5 km; |
| 5 - 10 d | As above except wind direction 36% frequency toward receptor at 5 km; |
| 11 - 30 d | As above except wind direction 31% frequency toward receptor at 5 km; |
| > 30 d | As above except wind direction 28% frequency toward receptor at 5 km; |

TABLE F.9: Weather Scenario for Ground Level Release, Trenton Airport

| Time after beginning of accident | Atmospheric conditions |
|---|---|
| 0 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100m; wind direction toward the nearest point on the boundary, steady wind direction; |
| 1 - 5 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m; wind direction toward the nearest point on the boundary, sector average; |
| 6 h | As above, except wind speed 1 m/s; |
| 7 h | As above, except wind speed 2 m/s; |
| 8 h | As above, except Pasquill E, wind speed 2 m/sec; |
| 9 h | Pasquill C, wind speed 0.5 m/s, mixing layer height 600 m-wind direction toward the nearest point on the boundary; |
| 10 h | Pasquill B, wind speed 0.5 m/s, mixing layer height 600 m-wind direction toward the nearest point on the boundary; |
| 11 - 12 h | Pasquill D, wind speed 2 m/s, mixing layer height 600 m-wind direction toward the nearest point on the boundary; |
| 13 h - 24 | 20% Pasquill D, wind speed 2 m/s, mixing layer height 600 m; 80% Pasquill F, wind speed 1 m/s; mixing layer height 100 m;<br>wind direction 42% frequency towards nearest point on the boundary; |
| 25 h - 2d | 50% Pasquill F, wind speed 1 m/s, mixing layer height 100 m;<br>50% Pasquill D, wind speed 2 m/s, mixing layer height 600 m;<br>wind direction 41% frequency towards nearest point on the boundary; |
| 3 - 10 d | 40 % Pasquill F, wind speed 1 m/s, mixing height 100 m;<br>60 % Pasquill D, wind speed 2 m/s, mixing height 600 m;<br>wind direction 30% frequency towards nearest point on the boundary; |
| 11 - 30 d | As above, except wind direction 21% frequency towards nearest point on the boundary; |
| > 30 d | As above, except wind direction 17% freqency towards nearest point on the boundary; |

TABLE F.10: Weather Scenario for the Elevated Release, Downwind Distance: 1 km, Trenton Airport

| Time after beginning of Accident | Atmospheric Conditions |
|---|---|
| 0 h | Pasquill D; wind direction 0.5 m/s, mixing layer height 600 m; wind direction toward the receptor at 1 km; |
| 1 - 3 h | Pasquill D; wind speed 0.5 m/s, mixing height 600 m; sector average; |
| 3 - 9h | As above, except wind speed 1 m/s; |
| 10h | Pasquill C, wind speed 1 m/s., mixing layer height 600 m; wind direction as above; |
| 11h | Pasquill E, wind speed 1 m/s, mixing layer height 100 m; wind direction as above; |
| 12 h | Pasquill D, wind speed 2 m/s, mixing layer height 600 m, wind direction as above; |
| 12 - 24h | Pasquill D, wind speed 2 m/s, mixing layer height 600 m; wind direction 41% toward the nearest point on boundary; |
| 25h - 2d | Pasquill B, wind speed 1 m/s, mixing layer height 600 m; wind direction as above; |
| 3 - 10d | 42% Pasquill D, wind speed 2 m/s; mixing layer height 600 m;<br>58% Pasquill E, wind speed 2 m/s, mixing layer height 100 m; wind direction 30% frequency toward receptor at 1 km; |
| 11 - 30d | As above, except wind direction 21% frequency toward receptor at 1 km; |
| > 30d | As above, except wind direction 17% frequency toward receptor at 1 km; |

TABLE F.11: Weather Scenario for the Elevated Release, Downwind Distance: 3 km, Trenton Airport

| Time after beginning of Accident | Atmospheric Conditions |
|---|---|
| 0 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m, wind direction toward the receptor at 3 km; |
| 1 - 4 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m, sector average; |
| 5h | Pasquill D, wind speed 0.5 m/s, mixing layer height 600 m; wind direction toward receptor at 3 km; |
| 6h | Pasquill F, wind speed 1 m/s, mixing layer height 100 m; wind direction toward receptor at 3 km; |
| 7h | Pasquill C, wind speed 0.5 m/s, mixing layer height 600 m; wind direction as above; |
| 8h | Pasquill E, wind speed 2 m/s, mixing layer height 100 m; wind direction as above; |
| 9h | Pasquill C, wind speed 1 m/s, mixing layer height 600 m; wind direction as above; |
| 10h - 12h | Pasquill D, wind speed 2 m/s, mixing layer height 600 m; wind direction as above; |
| 13 - 24h | Pasquill F, wind speed 1 m/s, mixing layer height 100 m; wind direction 41% frequency toward receptor at 3 km; |
| 25h - 2d | 55% Pasquill F, wind speed 1 m/s, mixing layer height 100 m;<br>45% Pasquill D, wind speed 2 m/s, mixing layer height 600 m;<br>wind direction as above. |
| 3 - 10d | 45% Pasquill F, wind speed 1 m/s, mixing layer height 100 m;<br>55% Pasquill D, wind speed 2 m/s, mixing layer height 600 m;<br>wind speed direction 30% frequency toward receptor at 3 km; |
| 11 - 30d | As above, except wind direction 21% frequency toward receptor at 3 km; |
| > 30 d | As above, except wind direction 17% frequency toward receptor at 3 km. |

TABLE F.12: Weather Scenario for the Elevated Release, Downwind Distance: 5 km, Trenton Airport

| Time after beginning of Accident | Atmospheric Conditions |
|---|---|
| 0 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m, wind direction toward receptor at 5 km; |
| 1 - 5 h | Pasquill F, wind speed 0.5 m/s, mixng layer height 100 m, sector average; |
| 6h | As above, except wind speed 1 m/s; |
| 7h | As above, except wind speed 2 m/s; |
| 8h | As above, except Pasquill E, wind speed 2 m/s; |
| 9h | Pasquill C, wind speed 0.5 m/s, mixing layer height 600 m; wind direction toward receptor at 5 km; |
| 10 - 12h | Pasquill D, wind speed 2 m/s, mixing layer height 600 m; wind direction toward receptor at 5 km; |
| 13 - 24h | Pasquill E, wind speed 1 m/s, mixing layer height 100 m; wind direction 41% frequency towards receptor at 5 km; |
| 25h -2d | 50% Pasquill F, wind speed 1 m/s, mixing layer height 100 m;<br>50% Pasquill D, wind speed 2 m/s, mixing layer height 600 m;<br>wind direction 41% frequency towards receptor at 5 km; |
| 3 - 10d | Pasquill F, wind speed 2 m/s, mixing layer height 100 m; wind direction 30% frequency towards nearest point on the boundary. |
| 11 - 30d | Pasquill F, wind speed 2 m/s, mixing layer height 100 m; wind direction 21 % frequency towards nearest point on the boundary. |
| > 30d | As above, except wind direction 17% frequency towards nearest point on the boundary. |

# G. RECOMMENDED "REALISTIC CONSERVATIVE" WEATHER SCENARIOS, CONCLUSIONS AND RECOMMENDATIONS

The summary weather scenarios presented in Chapter F (Tables F.1-F.12) are site-specific. As discussed in Chapter F, these scenarios do not differ significantly from site to site, indicating the robustness of the method of pattern analyses developed for this project, as well as giving confidence in the use of an appropriately constructed single scenario for other sites with no data.

In order to obtain a single "realistic conservative" weather scenario for each of the four release situations (ground-level releases and elevated releases for 1, 3 and 5 km), the respective weather scenarios for the three sites were compared. The "most conservative" atmospheric condition of the three sites at each time interval is determined using the ordering in Table E.1 and this is taken to be the "realistic conservative" atmospheric condition for the time interval. These "realistic conservative" weather scenarios for ground-level release and elevated releases for 1, 3 and 5 km are given in Tables G.1-G.4 respectively. These scenarios are intended for use within the N288.2 framework (i.e., with sector averaged equations for prolonged-and long-term releases and for windspeed less than 2 m/s).

In substantiating the recommended scenarios, "real" stability-wind speed scenarios were selected from the meteorological data for St. John Airport. Just for demonstration purposes, the criteria for selecting these scenarios were (i) the calculated time integrated concentration for the scenario has to fall within 1.5% of the $\chi_{10-720}$ (0.08993 $Ci{\cdot}s/m^3$) for St. John Airport, (ii) the weather conditions for the first six consecutive hours must be "61." Sixteen 720 hr scenarios fulfill these two criteria within the 5 year period analyzed. Two of them (which were chosen arbitrarily) are shown in Figures G.1a and 1b. Also shown in the figures are the scenarios recommended by this work. The realistic conservatism of the recommended scenarios without a loss of practicality is evident from these figures.

The time integrated concentrations that would result from the recommended scenarios when used with the short-term equation B.1 are compared with the AECB Staff Position scenarios in Tables G.5 and G.6 for various release durations. In Table G.5, the time integrated concentration resulting from the recommended scenarios and the AECB staff position scenarios using the N288.2 framework (CSA, 1983) are also shown. Also, note that the time integrated concentrations in these tables beyond 8 hours are lower than the corresponding $\chi_{10-t}$, for example, in Table E.6 due to inclusion of wind direction variations.

In general, the recommended scenarios yield higher time integrated concentrations than the Staff Position scenarios. The reasons are mainly two-fold.

The first reason lies in the representative wind speeds selected for each wind speed class (see Table B.3 and the discussion in Chapter B.2), that the lower limit of each range is taken as the representative wind speed for the corresponding wind speed class. The effect of taking the average wind speed as representative should be investigated for the recommended scenarios.

The second reason, which primarily affects the longer duration scenarios, lies in the frequency of occurrence of the same wind direction within a given release duration. For example, in the Staff Position scenarios for release durations of greater than thirty days the wind direction is assumed random (i.e., 6.25% in a given sector), but in the recommended scenarios it is 28%, mainly due to the high frequency of occurrence of a preferred wind direction in data from the Quebec Airport that is as a result of channelling by the St. Lawrence River Valley and nearby ridges (compare, for example, Tables F.1, F.5, and F.9, for times greater than 25 hours).

The scenarios given in Tables G.1-G.4 are designed for general use in safety analyses of nuclear power plants with incomplete site-specific meteorological data and they are recommended for use only under those circumstances, i.e., when adequate on-site or representative weather station data are not available. An in-depth study of what would constitute adequate data has been recently completed by Concord Scientific and reported elsewhere (Alp and Lewis, 1985). For preliminary safety analyses, use of meteorological data from a representative weather station, if available, is preferable over the use of the recommended scenarios. For final safety analyses, use of on-site data are recommended. A discussion of how safety analyses should be conducted when on-site or representative station data for appropriate periods are available (for example see US NRC, Reg. Guide 1.145, 1983), is beyond the scope of the present project. It should suffice to say that the available data set should be used directly and not used for deriving weather scenarios.

Throughout this research program, several areas have been identified which are recommended that they be investigated further. Some of these have already been pointed out in the report. These are now summarized below in point form.

It is recommended that:

1. the effect of taking an average wind speed as the representative wind speed for each wind speed class be investigated,
2. use of a more representative wind speed for the lowest wind speed class, or use of an entirely different dispersion model suitable for low wind speeds, be investigated,
3. effect of lake- and sea-breeze situations on the recommended scenarios be investigated,
4. the effect of taking meandering and sector averaging into account throughout the pattern analysis be investigated,
5. sensitivity of the weather condition rankings (Table E.1) to changes in the input parameters, such as building wake correction and surface roughness, be investigated,
6. the site-specific meteorological data and resulting scenarios be further critically examined with respect to site-specific topography. This will lead to a better understanding of the influence of terrain features on the recommended scenarios and will be useful in applying the general scenarios to other specific sites,
7. meteorological station site-specific topography be compared with the characteristics of nuclear plant sites,

8. time-integrated concentrations for real scenarios of different durations for one site be calculated, taking into account wind direction changes as they occur, and compared with those estimated using the recommended scenarios; this would be done using the dispersion model as used in the present study, to isolate the effects of the dispersion model from the pattern analysis method,
9. sensitivity of the scenarios to changes in the 10% exceedance criterion defined in the Introduction be investigated,
10. the implications of the recommended scenarios on dose calculations be examined,
11. the recommended scenarios be reviewed as more suitable data, such as mixing layer heights, and more refined dispersion models, become available.

Recommendation 8 is the most direct test of the pattern analyses method and the applicability of the recommended scenarios. Recommendations 1-4 and 11 are related to refining the data and the dispersion model used in the study. Recommendation 10 is aimed at making the recommended scenarios more suitable for dose calculations, which are among the primary objectives of safety analyses.

TABLE G.1: "Realistic Conservative" Weather Scenario for Ground Level Release

| Time after beginning of accident | Atmospheric conditions |
|---|---|
| 0 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100m; wind direction toward the nearest point on the boundary, steady wind direction; |
| 1 - 6 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m; wind direction toward the nearest point on the boundary, sector average; |
| 7h | As above except wind speed 1 m/s; |
| 8h | Pasquill D, wind speed 0.5 m/s, mixing layer height 600 m, wind direction as above; |
| 9h | Pasquill C, wind speed 0.5 m/s, mixing layer height 600 m, wind direction as above; |
| 10 - 12h | Pasquill D, wind speed 1 m/s, mixing layer height 600 m, wind direction as above; |
| 13 - 24h | 20% Pasquill D, wind speed 2 m/s, mixing layer height 600 m;<br>80% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; wind direction 58% frequency toward the nearest point on boundary; |
| 25h - 2d | Pasquill F, wind speed 2 m/s, mixing layer height 100 m, wind direction 58% frequency toward the nearest point on boundary; |
| 3 - 4d | 35% Pasquill D, wind speed 1 m/s, mixing layer height 600 m; 65% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; wind direction 43% frequency toward the nearest point on boundary; |
| 5 - 10d | As above except wind direction 36% frequency toward the nearest point on boundary; |
| 11 - 30d | As above except wind direction 32% frequency toward the nearest point on boundary; |
| >30d | As above except wind direction 28% frequency toward the nearest point on boundary; |

TABLE G.2: "Realistic Conservative" Weather Scenario for the Elevated Release Downwind Distance: 1 km

| Time after beginning of accident | Atmospheric conditions |
|---|---|
| 0 h | Pasquill D; wind direction 0.5 m/s, mixing layer height 600 m; wind direction toward the receptor at 1 km; |
| 1 - 4 h | Pasquill D; wind speed 0.5 m/s, mixing height 600 m; sector average; |
| 5h | As above except Pasquill C; |
| 6 - 12h | Pasquill D, wind speed 1 m/s, mixing layer height 600 m, wind direction as above; |
| 13 - 24h | 15% Pasquill D, wind speed 2 m/s, mixing layer height 600 m; 85% Pasquill E, wind speed 1 m/s, mixing layer height 100 m; wind direction 58% frequency toward receptor at 1 km; |
| 25h - 2d | Pasquill D, wind speed 2 m/s, mixing layer height 600 m, wind direction 58% frequency toward receptor at 1 km; |
| 3 - 4d | 20% Pasquill B, wind speed 1 m/s, 80% Pasquill D, wind speed 2 m/s, mixing layer height 600 m, wind direction 43% frequency toward receptor at 1 km; |
| 5 - 10d | As above except wind direction 36% frequency toward receptor at 1 km; |
| 11 - 30d | As above except wind direction 32% frequency toward receptor at 1 km; |
| >30d | As above except wind direction 28% frequency toward receptor at 1 km. |

TABLE G.3: "Realistic Conservative" Weather Scenario for the Elevated Release Downwind Distance: 3 km

| Time after beginning of accident | Atmospheric conditions |
|---|---|
| 0 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m, wind direction toward the receptor at 3 km; |
| 1 - 5 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m, sector average; |
| 6h | As above except wind speed 1 m/s. |
| 7h | Pasquill C, wind speed 0.5 m/s, mixing layer height 600 m, wind direction as above; |
| 8 - 9h | Pasquill D, wind speed 1 m/s, mixing layer height 600 m, wind direction as above; |
| 10 - 12h | Pasquill C, wind speed 1 m/s, mixing layer height 600 m, wind direction as above; |
| 13 - 24h | Pasquill F, wind speed 1 m/s, mixing layer height 100 m, wind direction 58% frequency toward receptor at 3 km; |
| 25h - 2d | 40% Pasquill D, wind speed 2 m/s, mixing layer height 600 m; 60% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; wind direction 58% frequency toward receptor at 3 km; |
| 3 - 4d | 45% Pasquill D, wind speed 2 m/s, mixing layer height 600 m; 55% Pasquill F, wind speed 1 m/s, mixing layer height 100 m; wind direction 43% frequency toward receptor at 3 km; |
| 5 - 10d | As above except wind direction 36% frequency toward receptor at 3 km; |
| 11 - 30d | As above except wind direction 32% frequency toward receptor at 3 km; |
| >30d | As above except wind direction 28% frequency toward receptor at 3 km. |

TABLE G.4: "Realistic Conservative" Weather Scenario for the Elevated Release Downwind Distance: 5 km

| Time after beginning of accident | Atmospheric conditions |
|---|---|
| 0 h | Pasquill F, wind speed 0.5 m/s, mixing layer height 100 m, wind direction toward receptor at 5 km; |
| 1 - 6 h | Pasquill F, wind speed 0.5 m/s, mixng layer height 100 m, sector average; |
| 7h | Pasquill F, wind speed 1 m/s, mixing layer height 100 m, wind direction as above; |
| 8h | Pasquill E, wind speed 2 m/s, mixing layer height 100 m, wind direction as above; |
| 9h | Pasquill D, wind speed 1 m/s, mixing layer height 600 m, wind direction as above; |
| 10h | Pasquill C, wind speed 0.5 m/s, mixing layer height 600 m, wind direction as above; |
| 11 - 12h | Pasquill D, wind speed 2 m/s, mixing layer height 600 m, wind direction as above; |
| 13 - 24h | Pasquill D, wind speed 0.5 m/s, mixing layer height 600 m, wind direction 58% frequency toward receptor at 5 km; |
| 25h - 2d | 25% Pasquill D, wind speed 2 m/s, 75% Pasquill D, wind speed 0.5 m/s, mixing layer height 600 m, wind direction 58% frequency toward receptor at 5 km; |
| 3 - 4d | Pasquill F, wind speed 2 m/s, mixing layer height 100 m, wind direction 43% frequency toward receptor at 5 km; |
| 5 - 10d | As above except wind direction 36% frequency toward receptor at 5 km; |
| 11 - 30d | As above except wind direction 32% frequency toward receptor at 5 km; |
| >30d | As above except wind direction 28% frequency toward receptor at 5 km. |

TABLE G.5: Comparison of the Time Integrated Concentration Calculated From the Weather Scenarios Recommended by the Staff Position and by This Work

| Duration of Release | $\chi$:Time Integrated Concentration | | | |
|---|---|---|---|---|
| | Staff Position | | This Work | |
| | $\chi$* | $\chi$** | $\chi$* | $\chi$** |
| 1 hr | 0.000282 | 0.000112 | 0.000564 | 0.000224 |
| 8 hr | 0.002256 | 0.001210 | 0.003793 | 0.001576 |
| 3 d | 0.01128 | 0.004792 | 0.009682 | 0.004257 |
| 10 d | 0.01807 | 0.006587 | 0.02246 | 0.01009 |
| 30 d | 0.03752 | 0.01172 | 0.05403 | 0.02450 |

* Calculated using the short term equation (based on Mourad, 1984; see Table E.1).

** Calculated using the N288.2 framework (CSA, 1983), i.e., the prolonged term equation for windspeed < 2 m/s or for duration of release > 1hr.

TABLE G.6: Comparison of the Time Integrated Concentration Calculated From the Weather Scenarios Recommended by the Staff Position and by This Work

Elevated Release (x = 1 km)

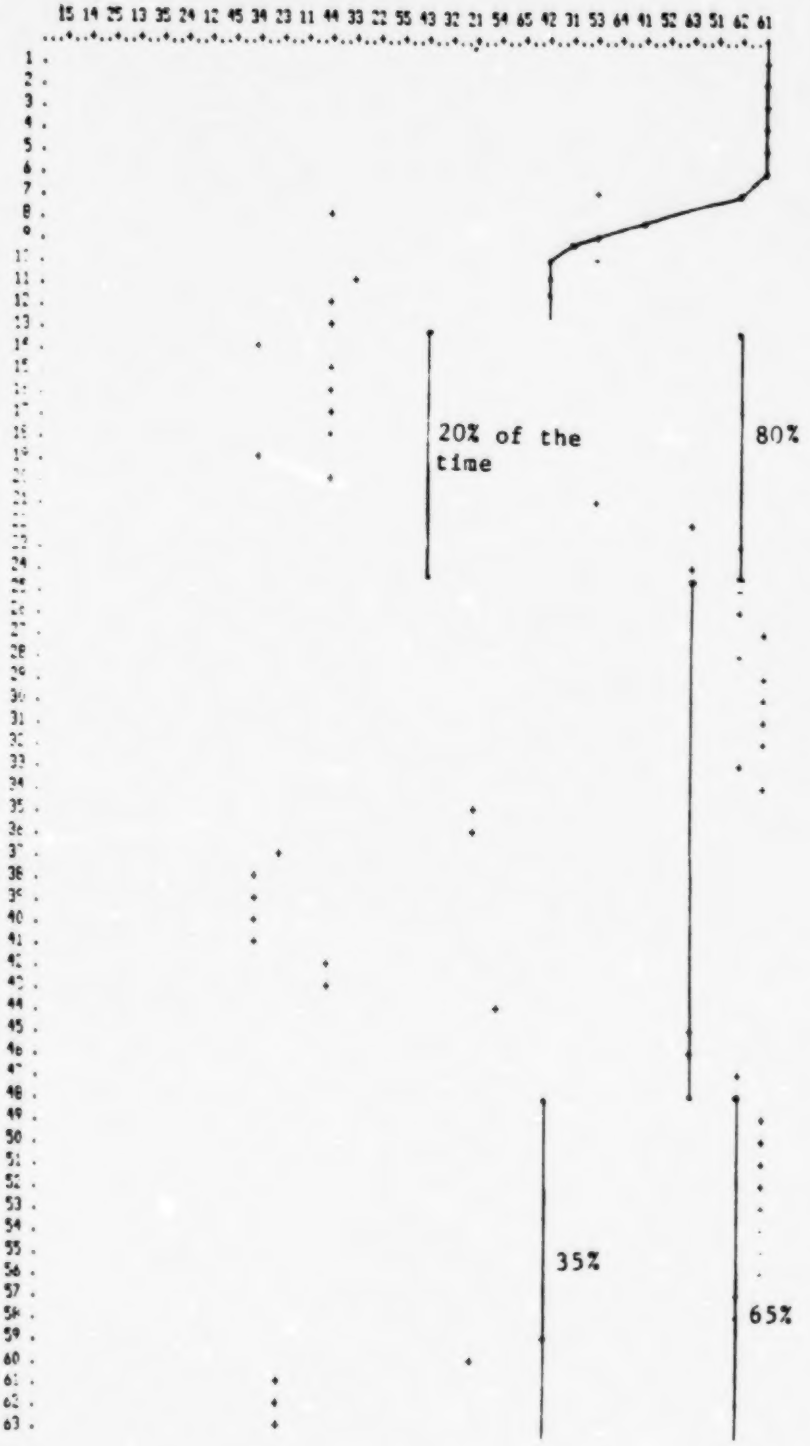
| Duration of Release | Time Integrated Conc.* (Ci•s•m$^{-3}$) | |
|---|---|---|
| | Staff Position** | This Work |
| 1 h | 0.0000331 | 0.0000662 |
| 8 h | 0.0002648 | 0.0004143 |
| 3 d | 0.0008696 | 0.001074 |
| 10 d | 0.001333 | 0.002110 |
| 30 d | 0.002656 | 0.004602 |

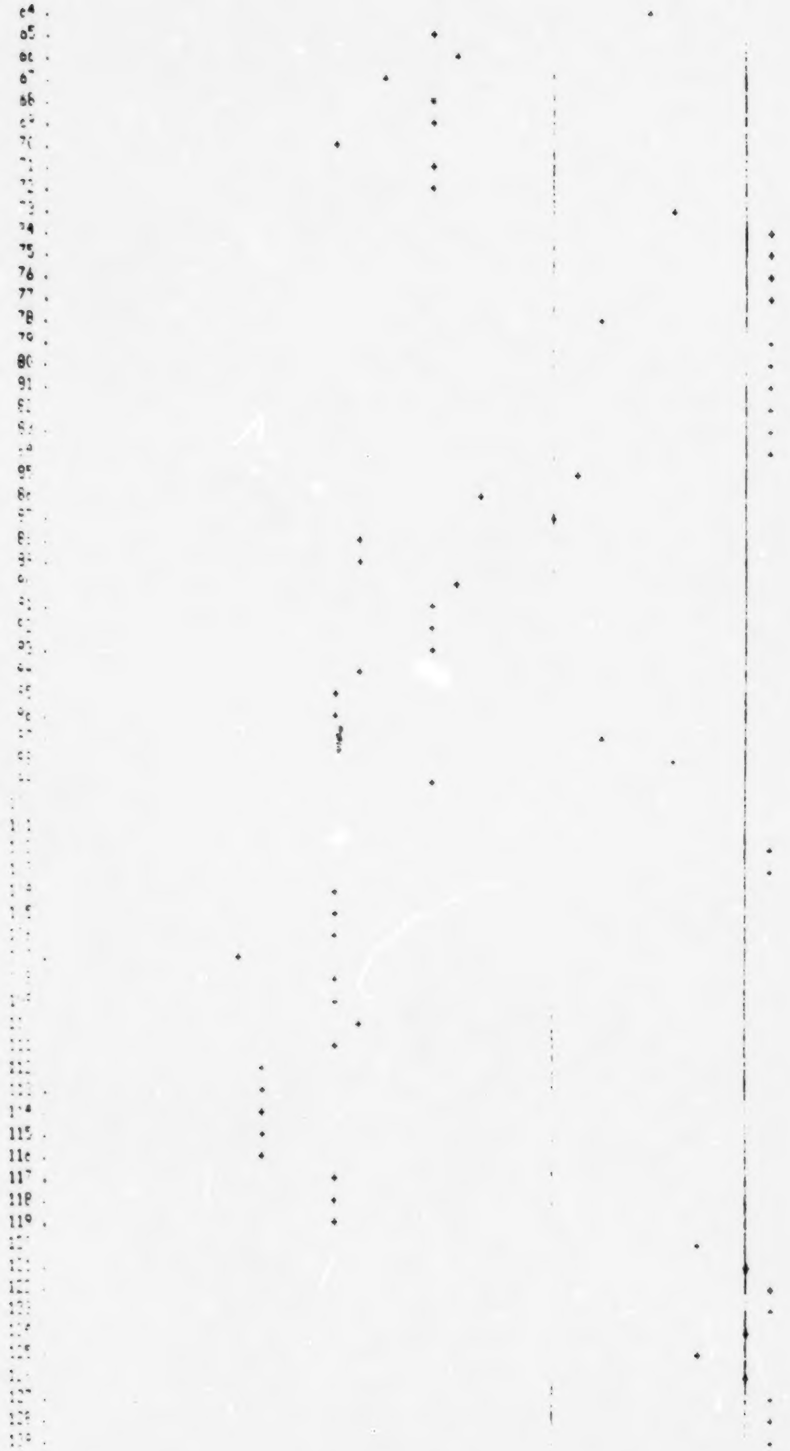
* Calculated using the short term equation (based on Mourad, 1984; see Table E.1)

** The atmospheric condition which produces the highest $\chi$ at 1 km was taken as the atmospheric condition recommended by the staff position.

FIGURE G.1a The Stability - Wind Speed 720 hr scenarios

+++ - "real" stability - wind speed scenario
____ - recommended stability - wind speed scenario

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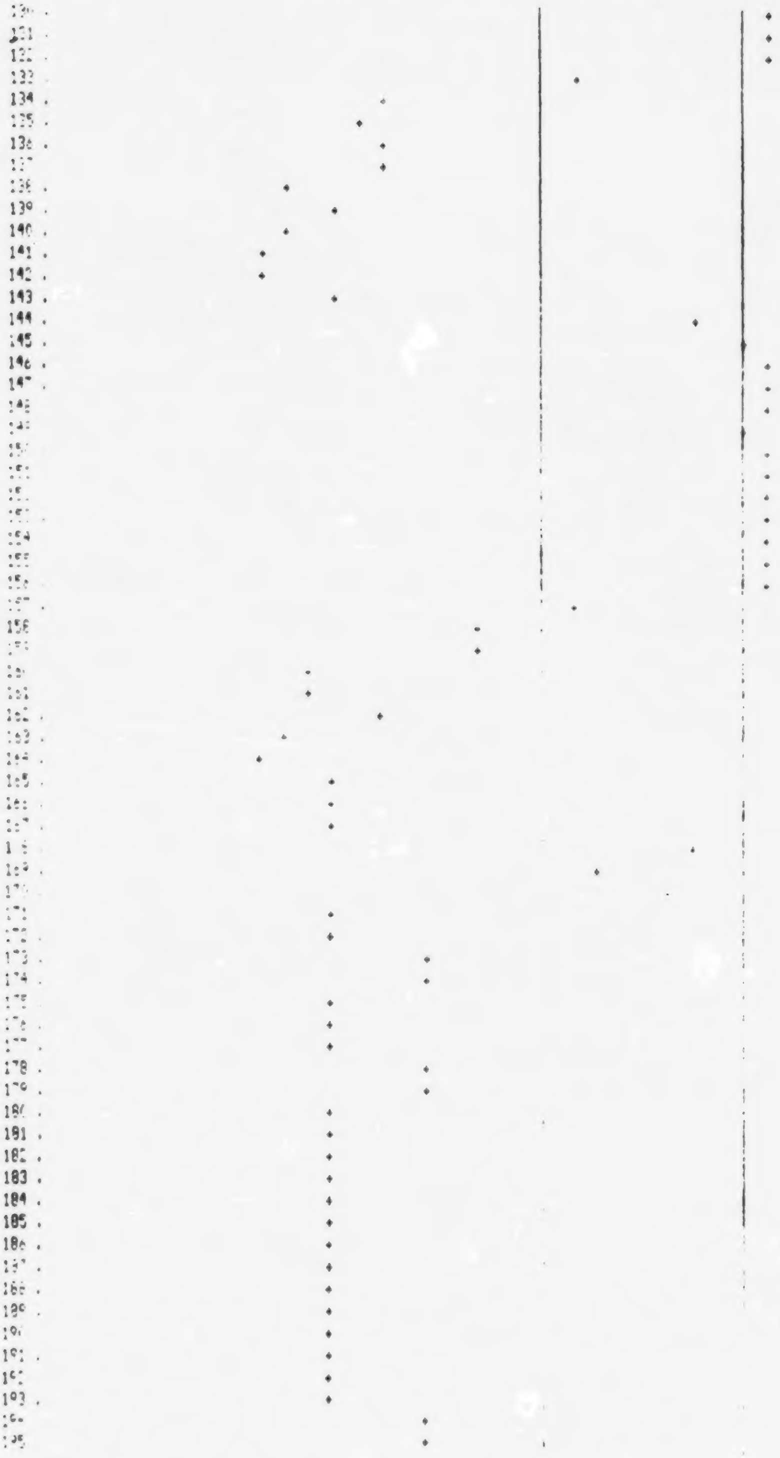
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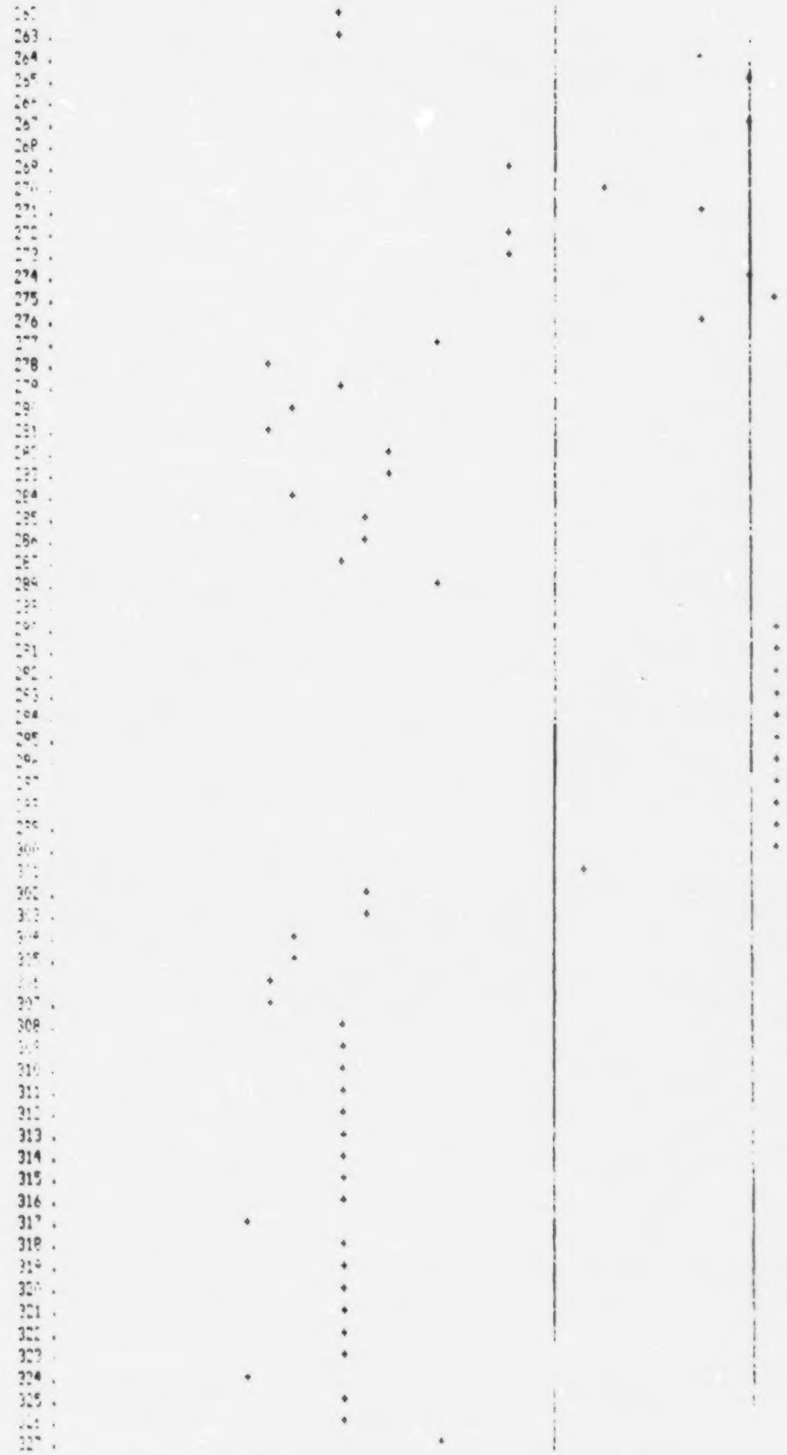
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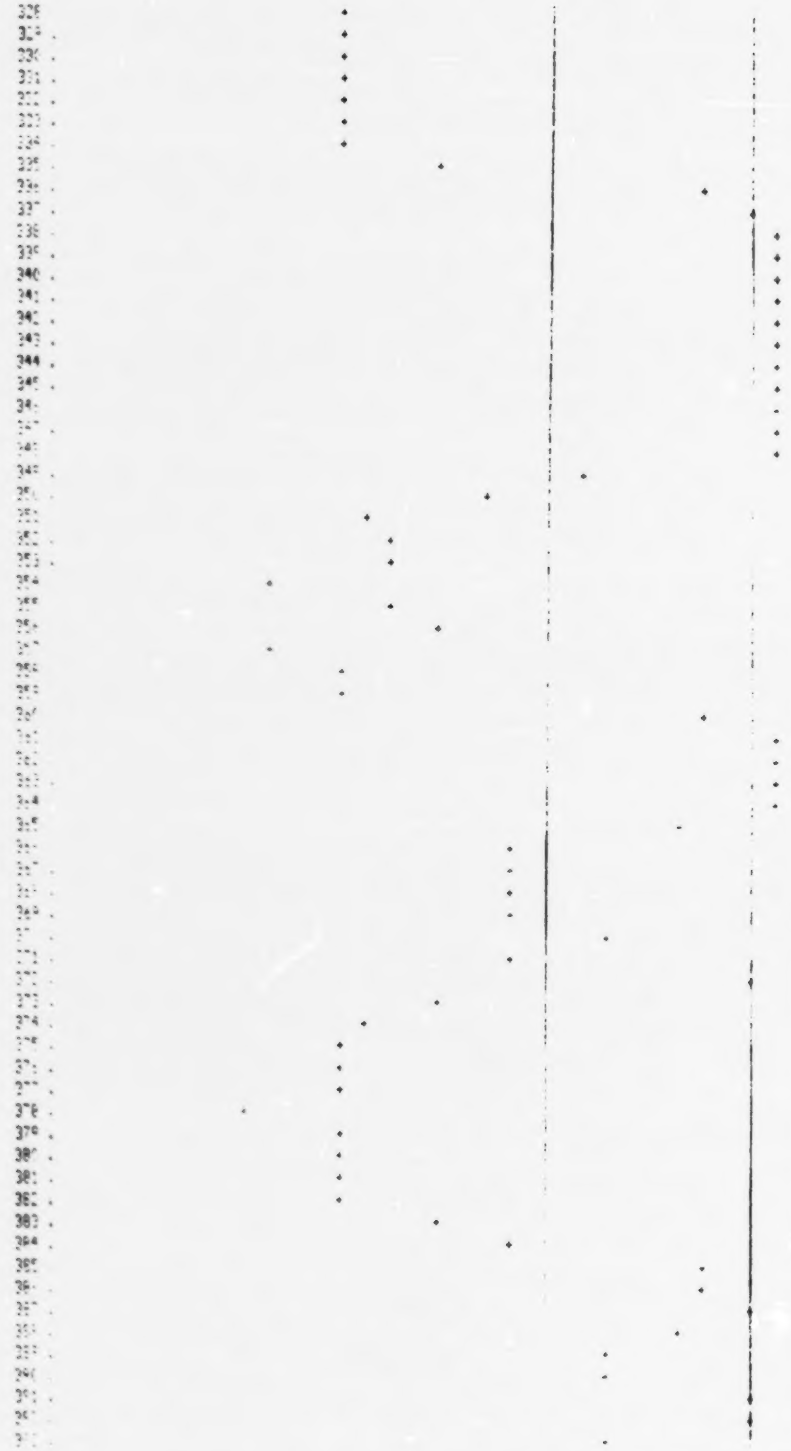

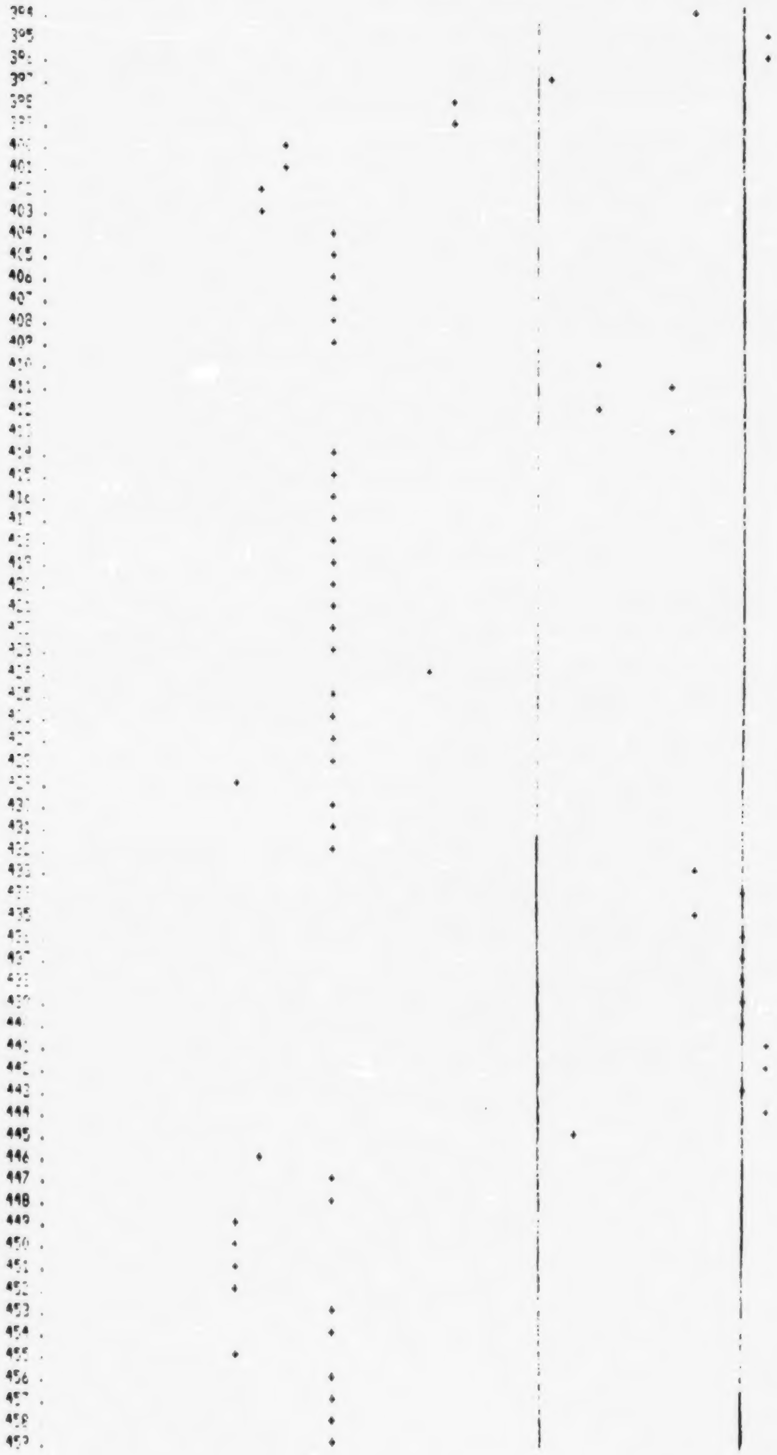
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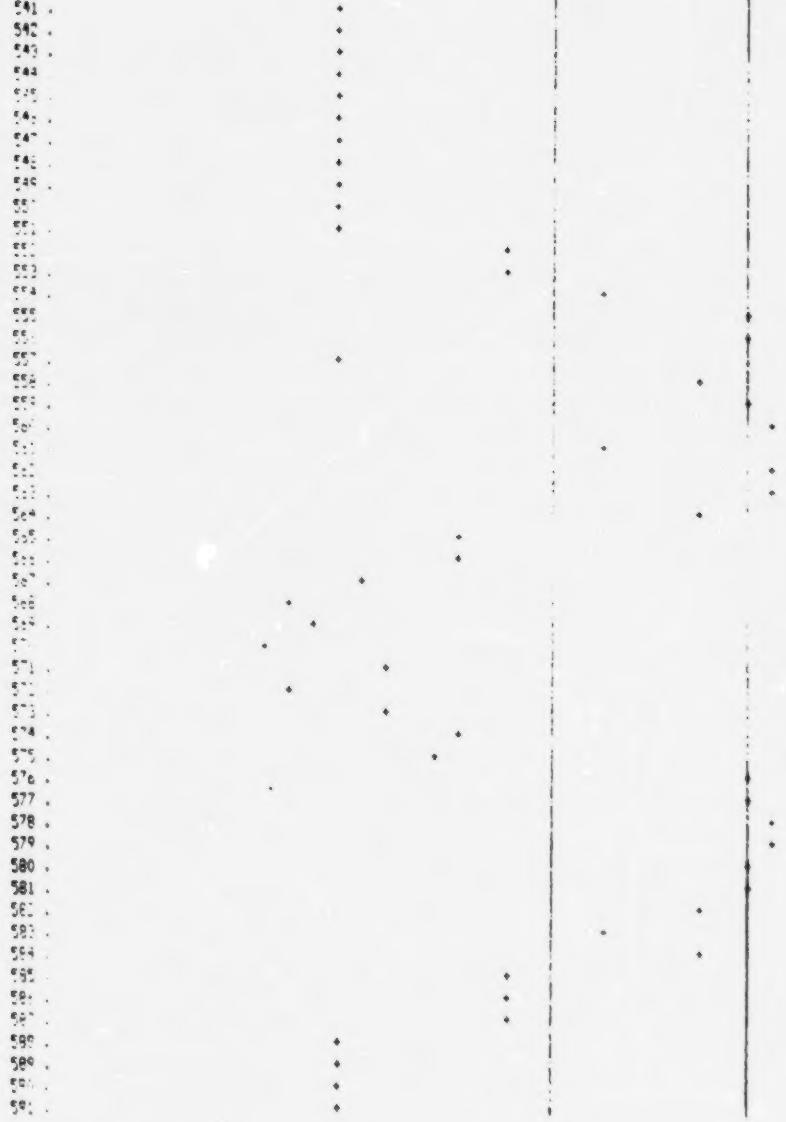
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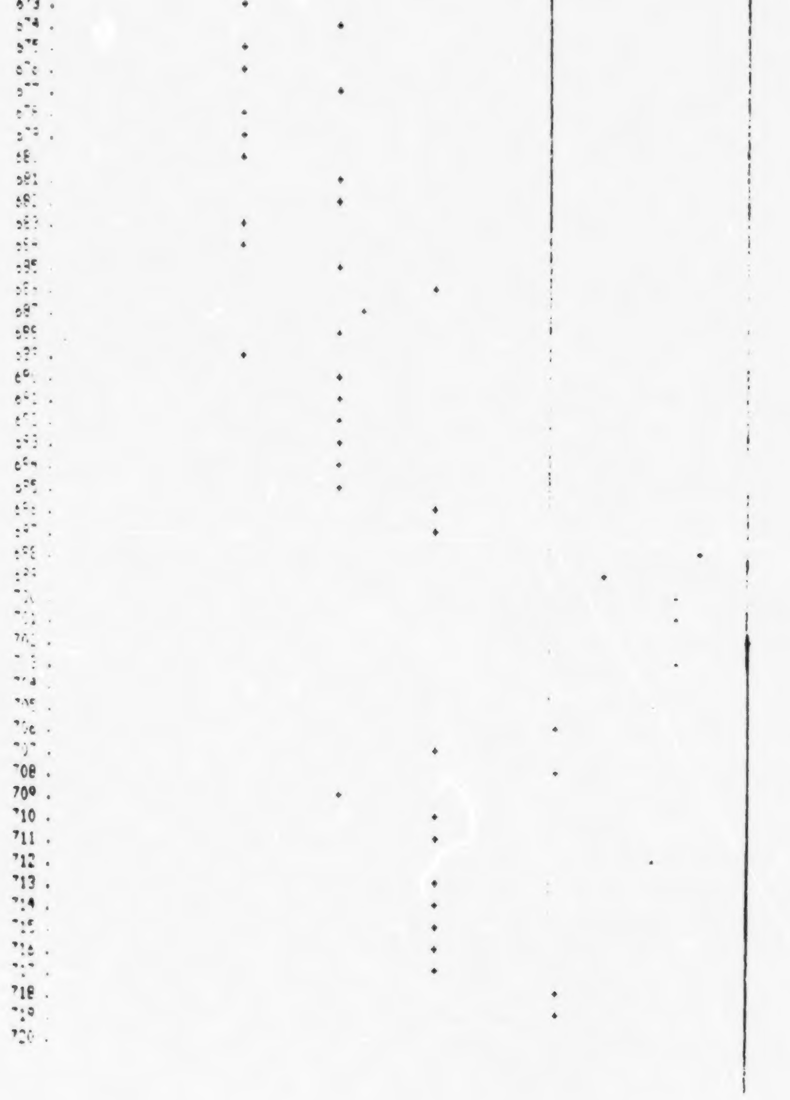
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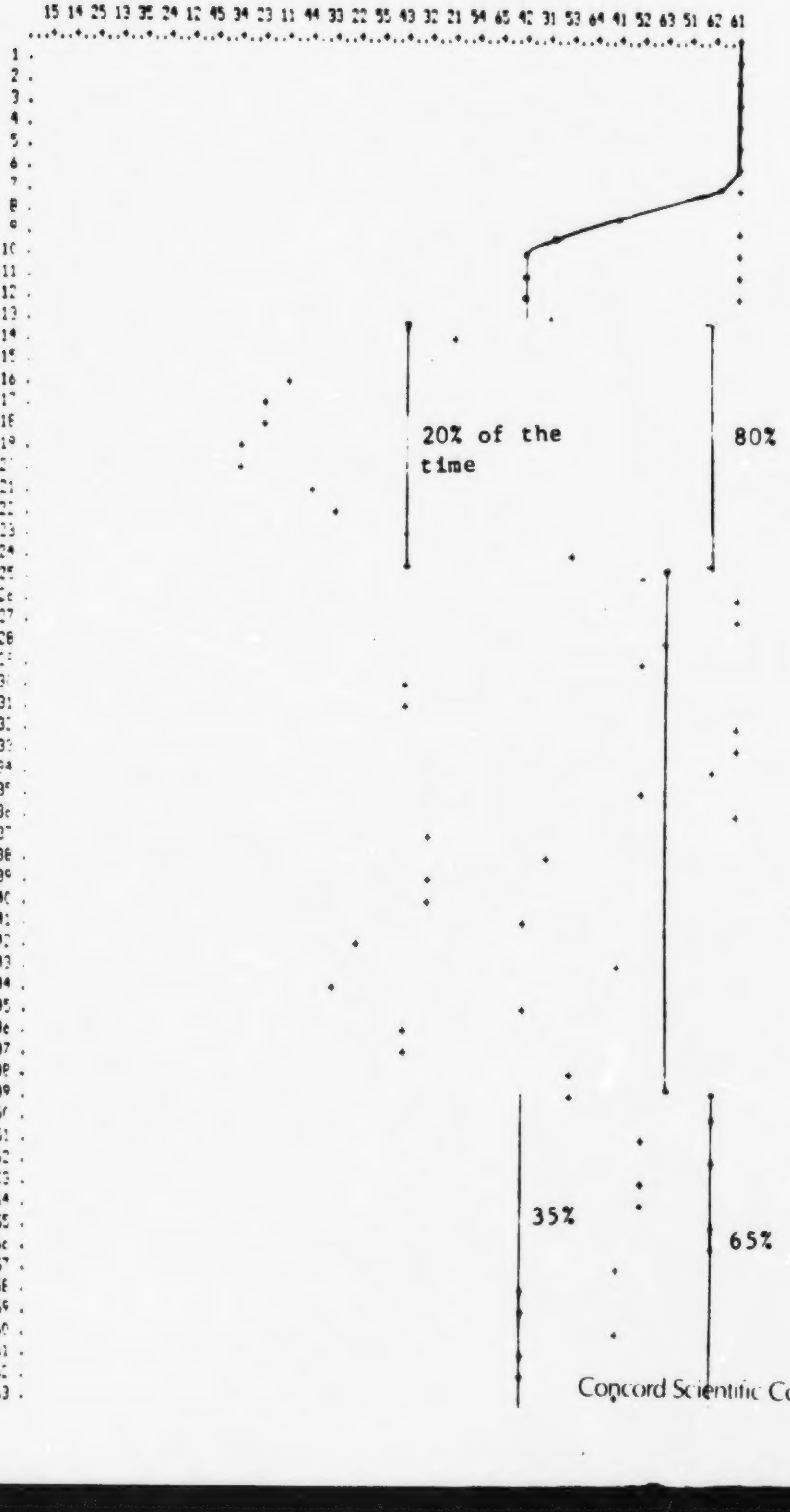
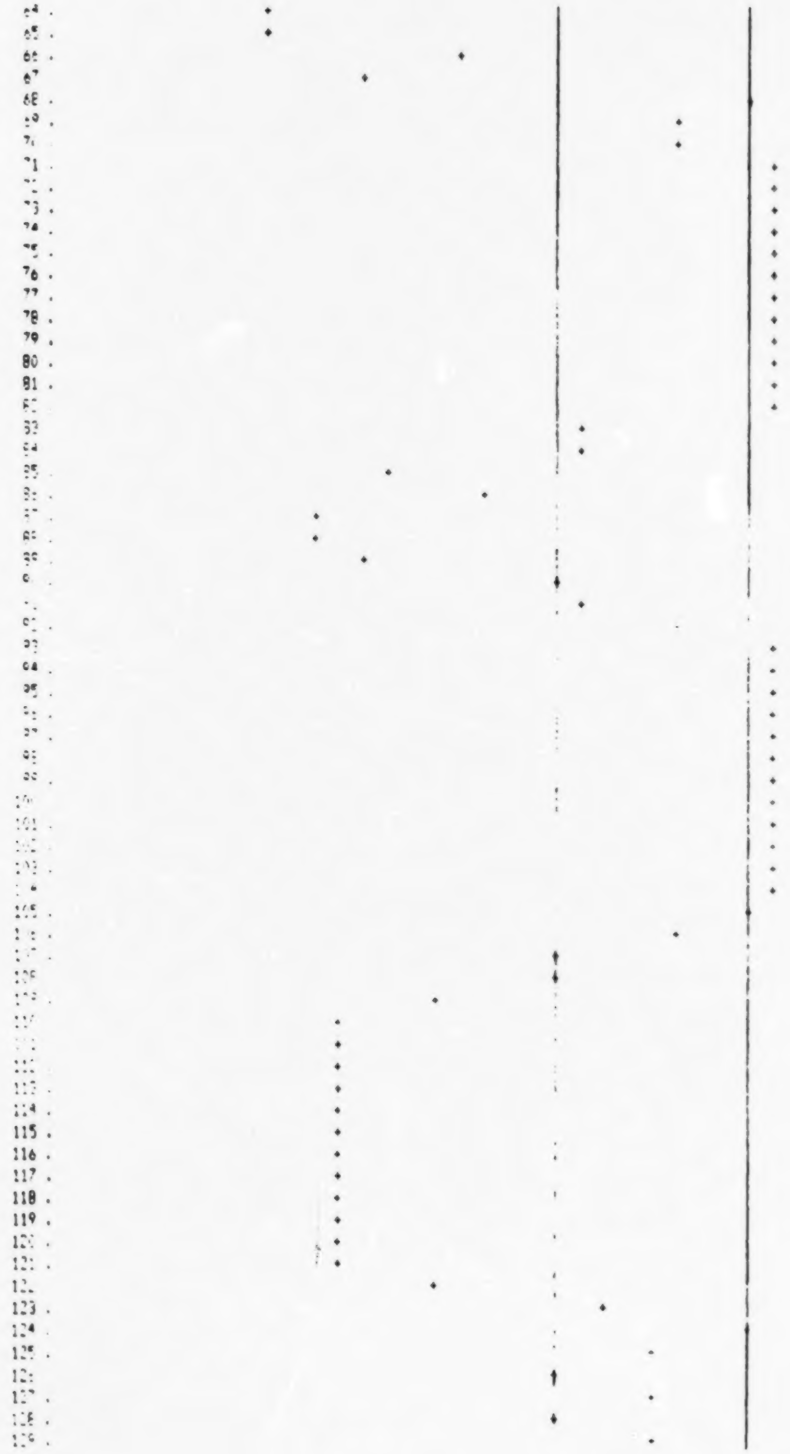
FIGURE G.1b The Stability - Wind Speed 720 hr scenarios

+++ - "real" stability - wind speed scenario
____ - recommended stability - wind speed scenario

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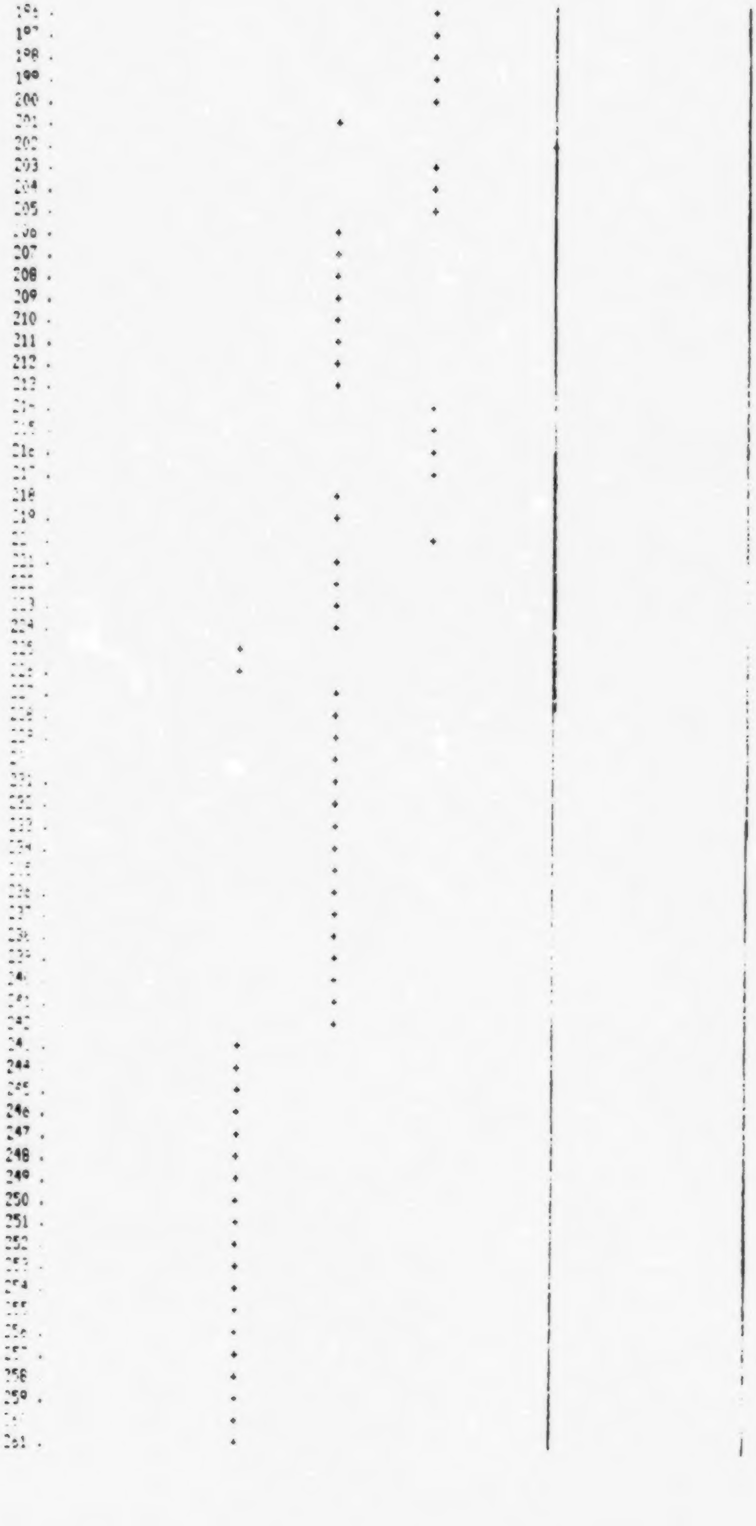

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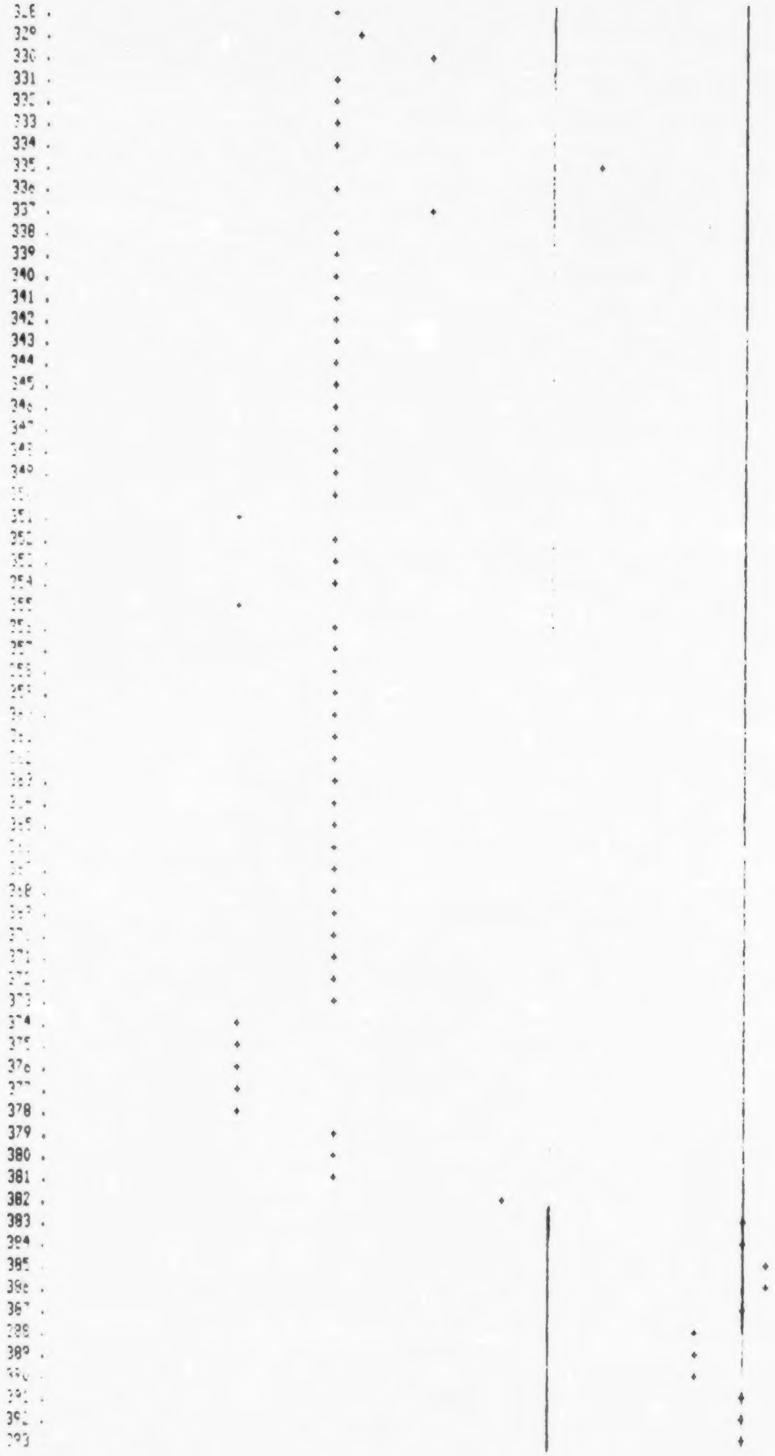
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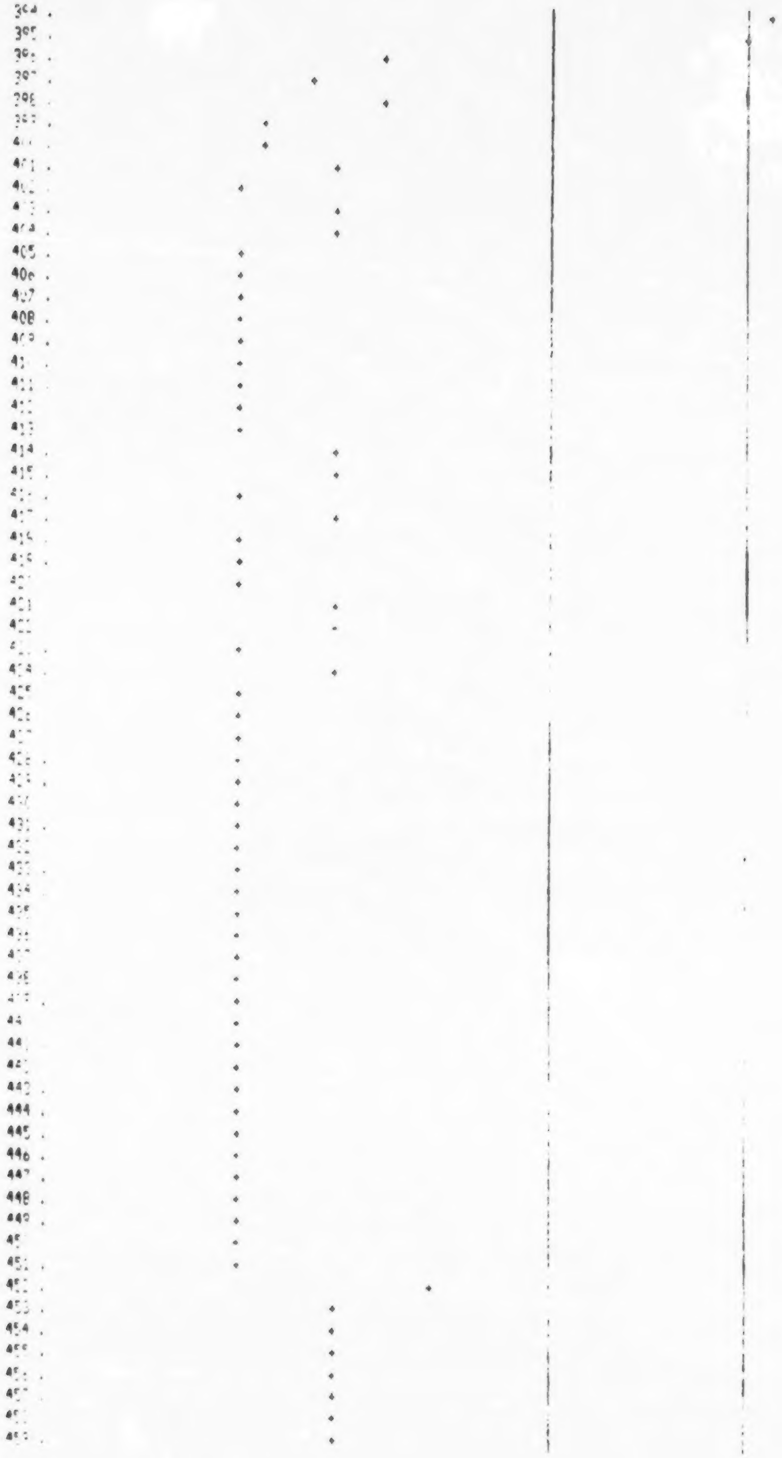

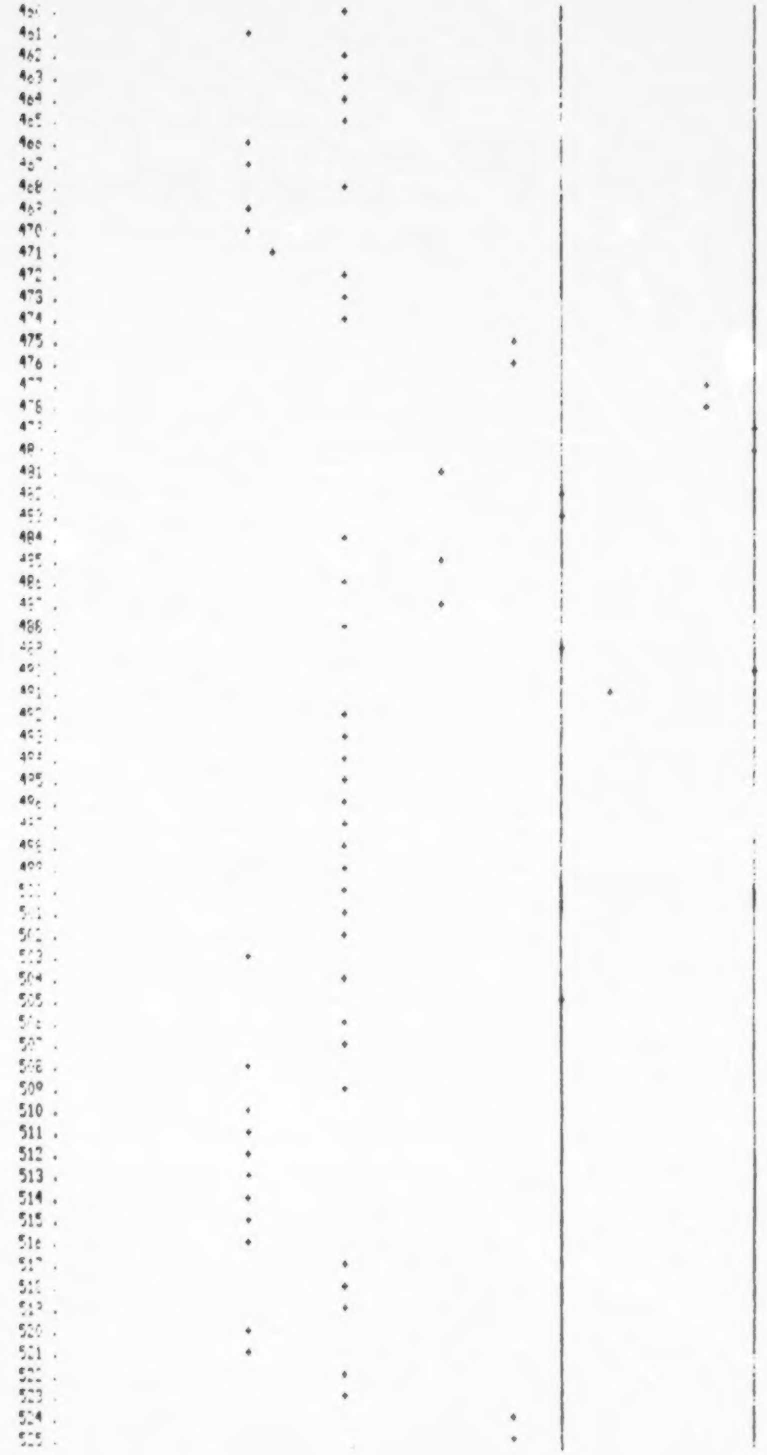
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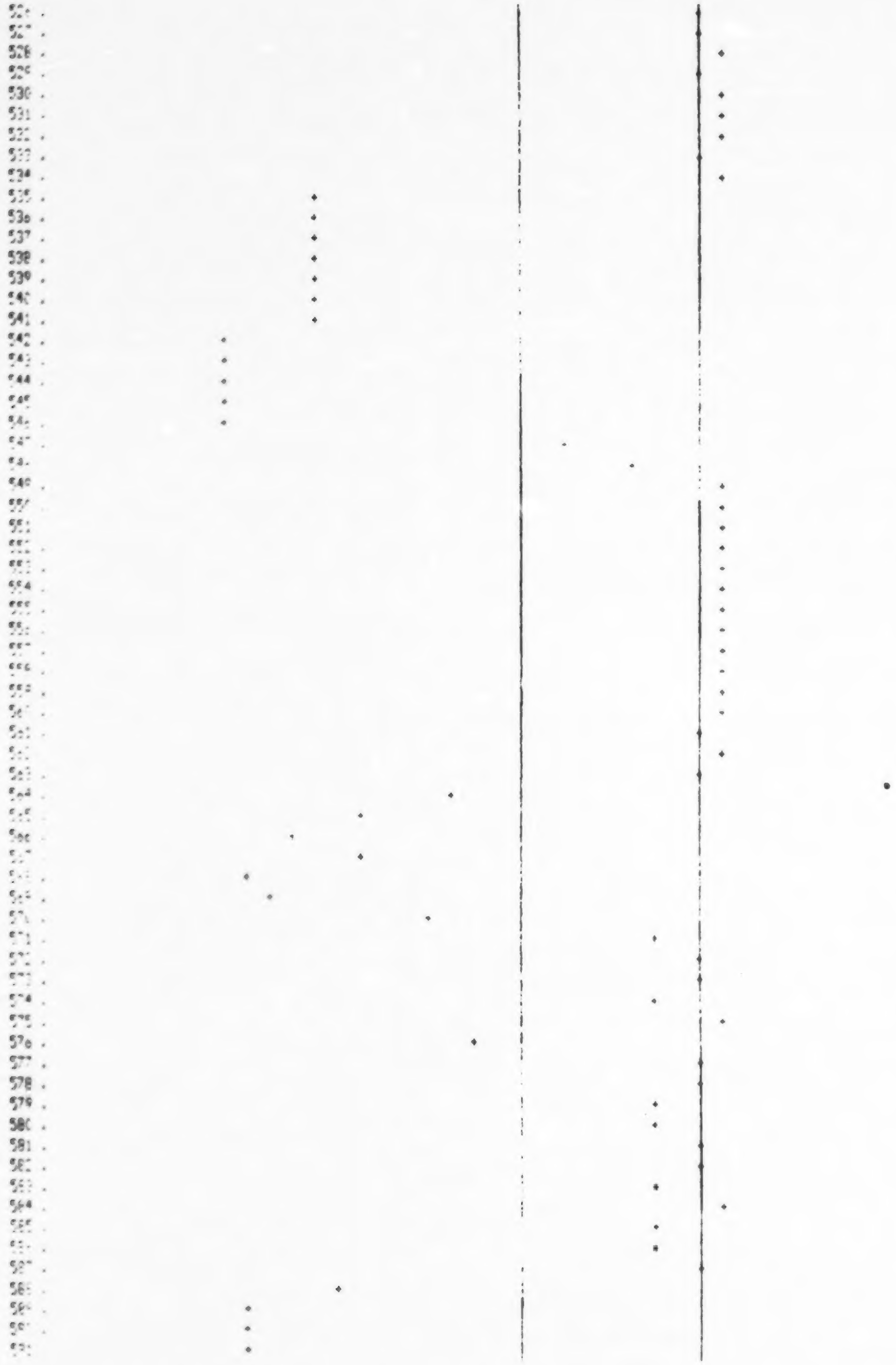

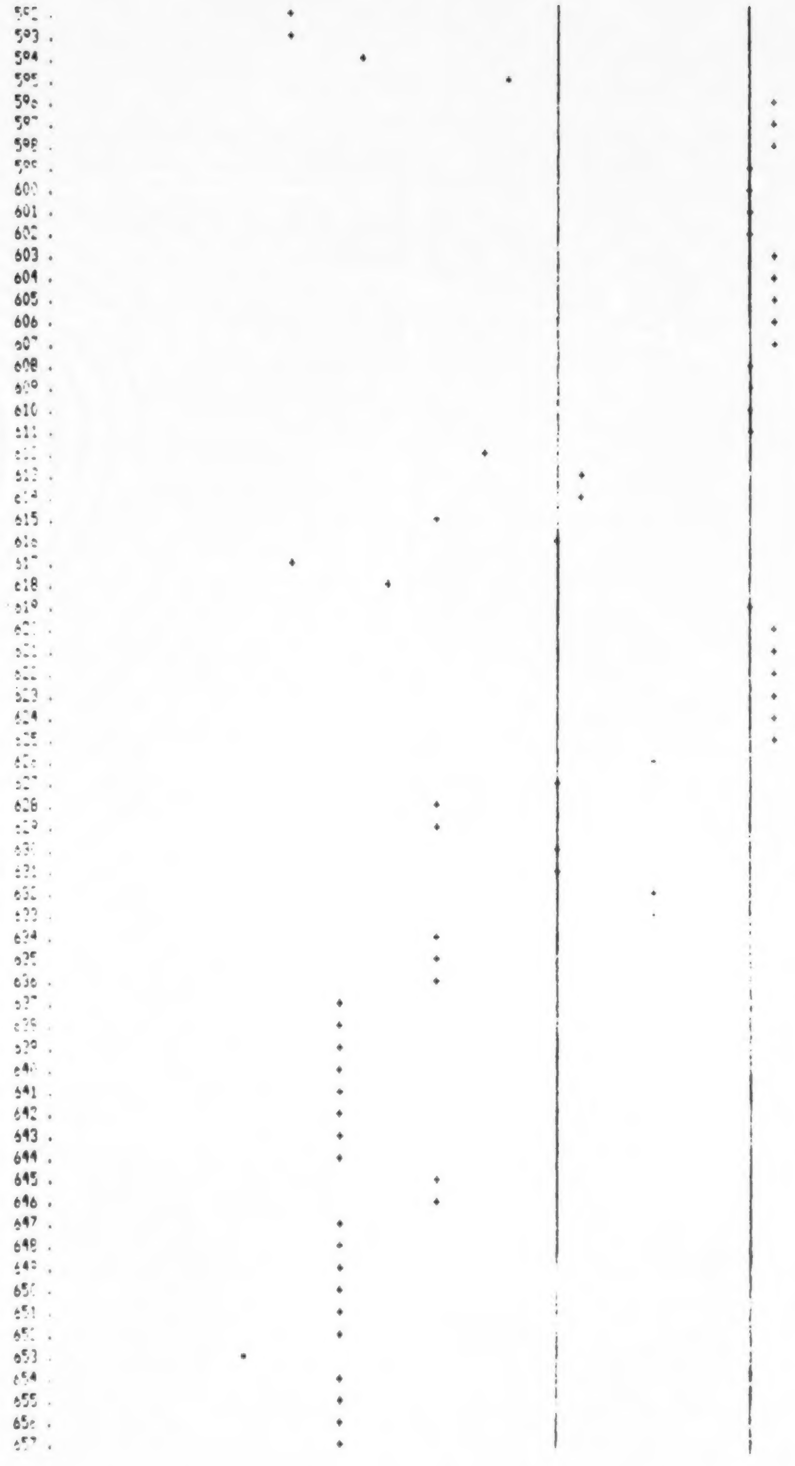
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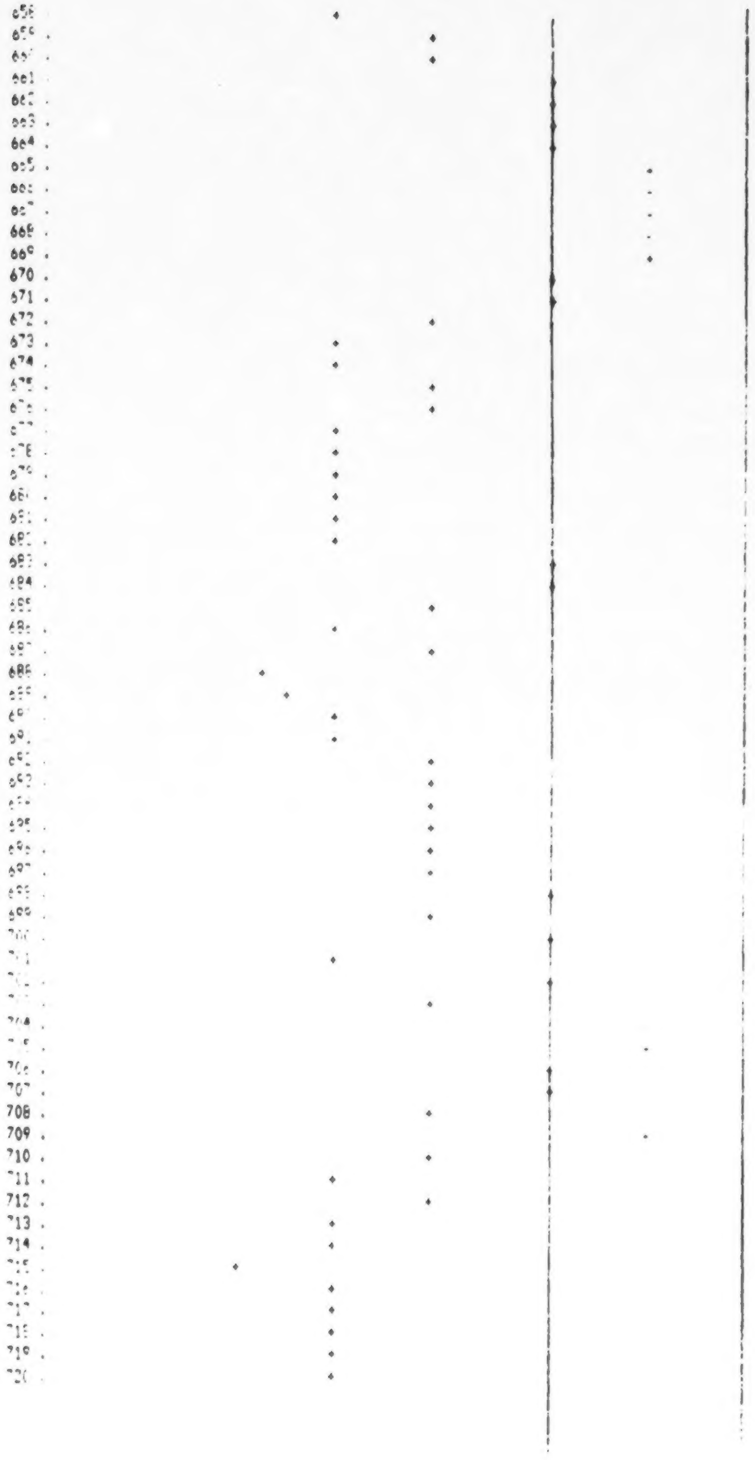
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